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VOLUME 90, NUMBER 1 JANUARY 29, 1946

SYMPOSIUM
on
ATOMIC ENERGY AND ITS IMPLICATIONS

Papers read at the Joint Meeting of
The American Philosophical Society
and
The National Academy of Sciences
November 16 and 17, 1945

THE AMERICAN PHILOSOPHICAL SOCIETY
INDEPENDENCE SQUARE
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FIFTY YEARS OF ATOMIC PHYSICS

H. D. SMYTH

Professor of Physics, Princeton University

(*Read November 16, 1945, in the Symposium on Atomic Energy and its Implications*)

INTRODUCTION

SINCE this is the first paper of a two-day session devoted to the atomic bomb, it seems appropriate to me to devote my talk to the development of atomic physics in the past fifty years in an attempt to recall to your minds the background on which the atomic bomb development rests. It is, in fact, just fifty years since the discovery of x-rays, a discovery which marked the beginning of the era of atomic physics. That period of fifty years is split in two by the First World War and terminates with the second. Let us begin by going back to the state of atomic theory in 1895.

ATOMIC THEORY IN 1895

The idea that all matter was made up of indivisible particles goes back to the time of the Greek philosophers. After many fluctuations of philosophical popularity it finally was put on a solid foundation of experimental chemistry in the nineteenth century. By 1895 the idea that matter consisted of atoms of some ninety different elements was reasonably well established. It had also been suggested that electrical charge was atomic. Attempts had been made from the kinetic theory of gases to estimate the number of molecules in a given quantity of gas and thereby the size of molecules. In fact, the first estimate was made by an Austrian, Loschsmidt, in 1865. Using later determinations of this number and the experimental results on electrolysis, an estimate had been made of the electrical charge carried by a single ion in solution. But all these quantitative data were uncertain and there were still many who did not accept the atomic hypothesis with enthusiasm.

THE STATE OF PHYSICS IN 1895

Furthermore, the question of whether or not atoms existed and the question of their structure, if anyone was so bold as to raise it, were considered the province of chemistry. The future of physics was estimated as follows:

> While it is never safe to affirm that the future of physical science has no marvels in store, even more astonishing than those of the past, it seems probable that most of the grand underlying principles have been firmly established and that further advances are to be sought chiefly in the rigorous application of these principles to all the phenomena which come under our notice.

This statement has been attributed to Professor Michelson; at least it appeared annually in the catalogue of the University of Chicago from about 1893 to 1906. Assuming what I might call a normal lag between a university catalogue and the views of a university faculty, this probably represents Michelson's views from say 1890 to 1900.

DISCOVERIES BETWEEN 1895 AND 1900

I have already mentioned the discovery of x-rays. It was made by Roentgen in Germany in 1895. His work was published and the news spread through the scientific world. As a consequence of this news, Becquerel in France discovered that uranium was radioactive. As is well known, work on radioactivity was carried on by the Curies and later by many others in many countries.

The third great discovery of this period was not so clear-cut. It was the discovery of the electron. The phenomena of cathode rays had been known for some thirty or forty years. In fact, there was a controversy between two schools of thought: the particle school and the wave school. Stoney had suggested the atomism of electrical charge as had Maxwell before him and had suggested the name electron for the atom of charge. Assuming that cathode rays were charged particles, Schuster had measured the ratio of charge to mass of these particles by their magnetic deflection. (I might here mention that the principle involved in Schuster's experiment is the same as used in mass spectrographs, in cyclotrons, and in the mighty electro-magnetic mass separators at Oak Ridge.) By 1899 J. J. Thomson had measured more accurately both the ratio of charge to mass and the velocity of cathode rays. The velocity had also been measured in Germany by Wiechert using a high-frequency method. The velocities proved to

be very great—of the order of one-tenth of the velocity of light. In other experiments the electrical charge carried by each particle had been determined and found to be approximately the same as that carried by a single ion in electrolysis. Perhaps most important of all, it had been shown that electrons could be obtained from all kinds of materials and that, whatever their source, they were always identical in charge and mass. Thus, electrons appeared as the first universal constituent of matter.

DEVELOPMENTS BETWEEN 1900 AND THE FIRST WORLD WAR

ATOMIC STRUCTURE

The idea that all matter was made of a few fundamental constituents was an old one. In particular, Prout in 1815 had suggested that the atoms of all elements were built up in some way from the lightest one, hydrogen. Prout's hypothesis was based on the belief that all chemical atomic weights were integral multiples of that of hydrogen, and it was given up when more exact atomic weight determinations gave values that were clearly not integral. The discovery that electrons were constituents of all elements gave renewed impetus to the study of atomic structure.

Evidently x-rays, cathode rays, and radioactivity all originated in some sort of atomic disruption. Yet their first contribution to the knowledge of atomic structure came from their use as probes to feel out the structure of other atoms rather than from a study of their own origin. Thus the study of the scattering of x-rays by different substances enabled Thomson to estimate how many electrons were in the atoms of different elements, while Rutherford's study of the scattering of the high-speed alpha particles revealed the distribution of mass and charge within the atoms.

Further evidence that all atoms might be made of the same particles in different arrangements came from the detailed study of the radioactive transformations. Such study showed that one radioactive element changes spontaneously into a different chemical element either by giving off an alpha particle or a beta particle and that all the radioactive elements go through series of successive transformations, eventually forming lead. Furthermore, it was proved that alpha particles are helium atoms that have lost two electrons.

As a result of many researches along these lines in Germany, France, Holland, England and a few in this country, the general picture of atomic structure which we now have was proposed by Rutherford in 1911. It is interesting to note that a similar idea had been suggested by Nagaoka of Japan in 1904. Rutherford's idea was that most of the mass of the atom was concentrated in a small nucleus which was positively charged and around which was a system of negatively charged electrons. By the time of the First World War, this picture had been confirmed and amplified by Mosley's discovery of x-ray spectra and by Bohr's theory of the arrangement of the electrons. The idea of isotopes, first introduced by Soddy in the radioactive field, had begun to be applied to non-radioactive elements, but its importance really belongs to the postwar epoch. Summarized briefly, the first twenty years of the atomic era established the existence of atoms, the existence of electrons, the general structure of atoms and its variation from element to element, but did not say much about the structure of the nuclei of atoms or about the possibilities of transmuting one kind of atom into another.

QUANTUM THEORY AND THEORY OF RELATIVITY

It was not only the experimental physicists who were busy between 1895 and 1915. In 1901 Planck in Germany proposed the quantum theory in its first form. Essentially this theory suggests that radiant energy is atomistic in character, or at least that the processes of absorption and emission of radiation occur in discontinuous steps or quanta. This theory was later developed by Einstein and others, and in particular was the keystone of Bohr's theory of atomic structure which I have already mentioned; for atomic bomb purposes, an even more signficant theoretical developmer.t was the suggestion by Einstein in 1905 that matter and energy were related by the equation, $E = mc^2$. This equivalence of matter and energy arose from the theory of relativity as developed by Einstein at that time. It is interesting to note that in his paper Einstein suggests that experimental proof of his equation might be found in the phenomena of radioacitivity. The direct experimental proof, however, was not forthcoming for twenty-five years.

THERMIONICS

Although the work on the emission of electrons by hot bodies that was done in this period is not very directly involved in atomic bomb development, I mention it because it is fundamental to the whole electronics industry which has been of great importance indirectly to the atomic bomb project.

PRINCIPAL CENTERS OF ACTIVITY IN THIS ERA

The first scientific journal in this country devoted exclusively to physics was founded in 1893. The American Physical Society was not founded until 1899. I am afraid this corresponds to the relatively small proportion of the work I have been reviewing which was done in this country. The great centers of research in physics were Cambridge and Manchester in England, Leyden in Holland, and various German universities. With a few notable exception such as Millikan and Michelson, the great names are European names: Rutherford, Bohr, Geiger, Richardson (an Englishman who worked in this country), Wien, Zeeman, Lorentz, Planck, Einstein, the Curies, etc.

THE PERIOD FOLLOWING WORLD WAR I

In the years immediately following the First World War the greatest activity in physics had to do with spectroscopy; that is to say, with the wave length of light emitted by various atoms under various circumstances. Such studies, coupled with simultaneous theoretical calculations, clarified our knowledge of the outer electronic structure of the various kinds of atom. It was possible to correlate these results with chemical information and to interpret chemical behavior in terms of electronic arrangement. These researches have little bearing on the atomic bomb project except through their influence on the development of the laws of quantum mechanics which govern not only the outer structure of an atom but the nucleus as well.

THE STUDY OF ISOTOPES

In the early 1920's Aston measured the exact masses of the atoms of many of the elements in the periodic table. As a result of these studies it was established that a given chemical element might have several isotopes; that is, atoms of different masses but the same chemical properties. Furthermore, it was observed that the masses of these isotopes were very nearly integral multiples of the mass of the hydrogen atom, the nucleus of which is called a proton. This suggested that all atoms were made up of two kinds of particles: electrons and protons; that the nuclei of atoms contained an integral number of protons which determined their mass and a smaller number of electrons of negligible mass but which neutralized the charges of some of the protons. The remaining positive charge on the nucleus determined the number of electrons in the outer system of the atom and therefore its chemical properties. We shall see presently that this picture is now modified.

BINDING ENERGIES

Aston did observe that the masses of the atoms were not quite exactly integral multiples of the mass of the proton. To explain this, Einstein's principle of the equivalence of mass and energy was invoked. According to this view, when particles are bound together in a nucleus their total mass is less than when they are free. This change in mass represents the energy released when the nucleus is synthesized, and, vice versa, represents the amount of energy that has to be used to break a nucleus into its component parts. Moreover, Aston found that there was a considerable variation in the binding energy per particle in different nuclei and that, in general, the nuclei of atoms in the middle part of the periodic table were more tightly bound than either the very light or very heavy nuclei. This led to the conclusion that, if a way could be found to break up heavy nuclei into medium-weight ones or to synthesize very light nuclei into medium-weight ones, energy would be released. Calculations showed that the amount of energy involved was very much larger than the amount involved in chemical reactions which depend only on rearrangement of the outer structure of the atoms. This was the first suggestion that there might be vast sources of untapped energy in atomic nuclei.

THE FIRST ARTIFICIAL TRANSMUTATION OF ELEMENTS

In 1919 Rutherford announced that he had succeeded in changing a few atoms of nitrogen into atoms of oxygen by bombarding them with alpha particles, and that in the course of this change a hydrogen nucleus or proton was ejected. Before Rutherford's experiments no attempt to produce nuclear changes artificially or to alter the rate of the natural nuclear changes in radioactive materials had succeeded.

Rutherford's experiments were on a minute scale and depended on alpha particles from rare radioactive substances. Consequently, progress was slow in this field. A good many similar experiments were performed, but there was no indication that nuclear energy could be released on a practical scale. However, between 1920 and 1932 technical developments in high-voltage equipment such as the development of the Van de Graaff generator and the cyclotron made it possible to pro-

luce artificial particles of almost as great energy as the alpha particles from radioactive substances.

SUMMARY OF THE STATE OF PHYSICS IN 1931

By the end of the first ten or twelve years after World War I the field of spectroscopy was beginning to be clearly understood. Quantum mechanics had been developed to such a point that progress was relatively slow and the field of nuclear physics was still limited by dependence on natural radioactive materials. No one would have made such a statement as that quoted at the beginning of this paper, for techniques were improving and it seemed likely that new discoveries would be made; but certainly new discoveries in theoretical and experimental physics were needed to revitalize research. Such discoveries came in a rush in 1932.

THE YEAR 1932

In 1932 Chadwick of England discovered the neutron. Like most scientific discoveries, this was in the nature of an extension, explanation, and clarification of previous experiments made earlier the same year by Irene Curie and F. Joliot in Paris and in 1930 by Bothe and Becker in Germany. The neutron is a particle of approximately the same mass as a proton but carrying no charge. As in the case of electrons, alpha particles, and x-rays, the discovery of the neutron promoted our knowledge of atomic structure in two ways. It could be used as a projectile to explore the structure of atoms, even to enter the atomic nuclei and disrupt them; also its existence could be used to simplify the picture we had of atomic structure—more specifically of nuclear structure. We now believe that all atomic nuclei are made of protons and neutrons, that the number of protons determines the atomic number and therefore the chemical nature of the atom, and that the nature of the nucleus depends on both the number of protons and the number of neutrons; and, in fact, in some cases the same numbers of protons and neutrons may be differently arranged so that nuclei having the same atomic number and the same mass number may have different nuclear properties. Up to the time of the discovery of neutrons the only heavy (as compared to electrons) projectiles which could be fired at atomic nuclei were the proton and the alpha particle. Both of these are positively charged and are therefore strongly repelled by the nuclei of the elements of high atomic number. The great advantage of the neutron as a projectile is its lack of charge.

Other major events in physics in 1932 were the discovery of the positron by Anderson and the discovery of heavy hydrogen by Urey, Brickwedde, and Murphy. Both these discoveries were made in this country. Finally, it was in the year 1932 that Cockcroft and Walton, in Rutherford's laboratory in England, first succeeded in producing nuclear changes by artificially-produced high-speed particles, and in proving by direct experiment that Einstein's equation, $E = mc^2$, was valid in nuclear changes.

The discovery of artificial radioactivity by Curie and Joliot in France was not made until 1934, but it really belongs in this general group of developments.

THE RISE OF PHYSICS IN THE UNITED STATES

It may be well at this point to digress from the main story in order to examine the change in the conditions of physics in this country. It was by no means an accident that heavy hydrogen and the positron were discovered by Americans. After the First World War interest in both theoretical and experimental research in physics increased greatly in this country. In particular, the establishment of national research fellowships by the Rockefeller Foundation, working through the National Research Council, gave an opportunity for many of the better young men to spend one to three years after receiving their Ph.D. in research at the leading universities in this country or abroad. The habit of research so developed persisted, and the influence of these men, both directly and indirectly, has been very great. Experimental physics, which had always been relatively strong, flourished particularly, with the resulting development of the Van de Graaff generator, the cyclotron, the mass spectrograph, and other devices. Theoretical physics, which had been almost nonexistent in this country before the war, also began to develop healthily. Yet it must be reported that most of the great discoveries in fundamental physics in the period between the two wars were made in Europe.

PRACTICABILITY OF ATOMIC POWER IN 1939

The discovery of the neutron and the multiplication of cyclotrons and the high-voltage devices rapidly led to many experiments on nuclear disintegration. Einstein's notion of the equivalence of matter and energy was repeatedly verified in this country and abroad. Yet in all these experiments the amounts of material involved were mi-

nute and the amounts of nuclear energy released were small compared to the energy expended in the experiment as a whole. It was evident that some sort of chain reaction among nuclei was needed to release appreciable quantities of energy. Such a chain reaction was indeed postulated by Bethe as the probable source of energy in the sun. His hypothesis suggested a series of six successive nuclear reactions, the net effect of which was the transformation of hydrogen into helium and the release of vast amounts of energy. Speculation was rife as to the possibilities of achieving a similar series of reactions in the laboratory, but no progress was made until the discovery of uranium fission.

THE DISCOVERY OF URANIUM FISSION

Beginning in 1934 Fermi in Rome studied the effect of neutron bombardment on the heaviest elements, in particular, uranium. The results were puzzling and were not properly interpreted until 1939 when Hahn and Strassmann in Germany proved that an isotope of barium was produced by neutron bombardment of uranium. This discovery was soon interpreted by Frisch and Meitner in Copenhagen, and their interpretation was verified there and in this country. It was shown that the absorption of neutrons by uranium resulted in the splitting or fission of the uranium nucleus into two approximately equal parts and that this act of fission released from one to three neutrons. Since the fission was itself caused by neutrons, the possibility of a chain reaction was at once apparent. Also, since the fission released enormous amounts of energy, millions of times greater than the energy released by the most violent explosives, the possibility of useful production of energy from nuclei became a probability. Interest in this discovery was of course world-wide, and its investigation was pursued by scientists in all countries with the result that a considerable body of information had already been published in the literature by the middle of 1940. Since that time most of the work has been done in secret, but it may be of interest to quote from my report [1] the summary of what was generally known about fission in 1940.

DEFINITE AND GENERALLY-KNOWN INFORMATION ON FISSION

All the following information was generally known in June 1940, both here and abroad:

(1) That three elements—uranium, thorium, and protoactinium—when bombarded by neutrons sometimes split into approximately equal fragments, and that these fragments were isotopes of elements in the middle of the periodic table, ranging from selenium ($Z = 34$) to lanthanum ($Z = 57$).

(2) That most of these fission fragments were unstable, decaying radioactively by successive emission of beta particles through a series of elements to various stable forms.

(3) That these fission fragments had very great kinetic energy.

(4) That fission of thorium and protoactinium was caused only by fast neutrons (velocities of the order of thousands of miles per second).

(5) That fission in uranium could be produced by fast or slow (so-called thermal velocity) neutrons; specifically, that thermal neutrons caused fission in one isotope, U-235, but not in the other U-238, and that fast neutrons had a lower probability of causing fission in U-235 than thermal neutrons.

(6) That at certain neutron speeds there was a large capture cross section in U-238 producing U-239 but not fission.

(7) That the energy released per fission of a uranium nucleus was approximately 200 million electron volts.

(8) That high-speed neutrons were emitted in the process of fission.

(9) That the average number of neutrons released per fission was somewhere between one and three.

(10) That high-speed neutrons could lose energy by inelastic collision with uranium nuclei without any nuclear reaction taking place.

(11) That most of this information was consistent with the semi-empirical theory of nuclear structure worked out by Bohr and Wheeler and others; this suggested that predictions based on this theory had a fair chance of success.

SUMMARY

1940 marked the end of forty-five years' work on atomic physics. Starting from a general notion that atoms probably existed, chemists and physicists had proved their existence and shown that they were built of protons, neutrons, and electrons, had developed the laws which govern the arrangement of the electrons in the outer structure, had developed the general picture of the nuclear atom, had learned something of nuclear structure, and finally had learned how to change one kind of nucleus into another—in other words, to transmute one element into another. They had released nuclear energy in the laboratory and had made the discoveries which would probably lead to the release of nuclear energy on a large scale, thus tapping a source of energy unknown on the earth

[1] *Atomic Energy for Military Purposes,* Princeton Univ. Press, 1945.

except in the rare radioactive elements. In the last twenty years of this period of advance science in this country had begun to reach maturity, and a large number of chemists and physicists competent in the field of atomic structure had been trained. But these men were still largely dependent on Europe for fundamental advances and, in many cases, for training.

CONCLUSION

In this paper I have not tried to review the actual development of the atomic bomb itself. This has been covered in many discussions of both a technical and popular nature in the past few months. Nor shall I try to look into the future, either scientifically or politically. I hope that the later papers on this program will consider the great questions which have been raised by the development of the atomic bomb; I do believe that the enormous strides made by the international cooperation of scientists up to 1940 and by the national cooperation of scientists, engineers, industrialists, and military men in the past five years may teach us something. I believe they show what men can do to solve very difficult problems by working together and they give us hope that men working together may solve the even more difficult political problems that face us.

ATOMIC WEAPONS

J. R. OPPENHEIMER

Professor of Theoretical Physics, California Institute of Technology and the University of California

(*Read November 16, 1945, in the Symposium on Atomic Energy and its Implications*)

WHAT you have good reason to wish to hear from me today, what circumstances have perhaps qualified me to discuss with you on the basis of experience, is how to make atomic weapons. It is true, as we have so often and so earnestly said, that in the scientific studies which we had to carry out at Los Alamos, in the practical arts there developed, there was little of fundamental discovery, there was no great new insight into the nature of the physical world. But we had many surprises; we learned a good many things about atomic nuclei and many more about the behavior of matter under extreme and unfamiliar conditions; and not too few of the undertakings were in their quality and style worthy of the best traditions of physical science. It would not be a dull story; it is being recorded in a handbook of fifteen volumes, much of which we think will be of interest to scientists even if they are not by profession makers of atomic bombs. It would be a pleasure to tell you a little about it. It would be a pleasure to help you to share our pride in the adequacy and the soundness of the physical science, of our common heritage, that went into this weapon, that proved itself last summer in the New Mexico desert.

That would not be a dull story; but it is not one that I can tell today. It would be too dangerous to tell that story. That is what the President, on behalf of the people of the United States, has told us. That is what many of us, were we forced ourselves to make the decision, might well conclude. What has come upon us, that the insight, the knowledge, the power of physical science, to the cultivation of which, to the learning and teaching of which we are dedicated, has become too dangerous to be talked of even in these halls? It is that question that faces us now, that goes to the root of what science is and what its value is; it is to that question to which tentatively, partially, and with a profound sense of its difficulty and my own inadequacy, I must try to speak today.

It is not a familiar question to us in these late days. It is not a familiar situation. If it seems to bear analogy to that raised by other weapons, to the need for a certain secrecy, let us say, in the discussion of howitzers or torpedoes, that analogy will mislead us. There are some accidents in this situation, some things that may in the large light of history seem contingent. Atomic weapons are based on things that are in the very frontier of physics; their development is inextricably entangled with the growth of physics, as in all probability with that of the biological sciences, and many practical arts. Atomic weapons were actually made by scientists, even, some of you may think, by scientists normally committed to the exploration of rather recondite things. The speed of the development, the active and essential participation of men of science in the development, have no doubt contributed greatly to our awareness of the crisis that faces us even to our sense of responsibility for its resolution. But these are contingent things. What is not contingent is that we have made a thing, a most terrible weapon, that has altered abruptly and profoundly the nature of the world. We have made a thing that by all the standards of the world we grew up in is an evil thing. And by so doing, by our participation in making it possible to make these things, we have raised again the question of whether science is good for man, of whether it is good to learn about the world, to try to understand it, to try to control it, to help give to the world of men increased insight, increased power. Because we are scientists, we must say an unalterable *yes* to these questions: it is our faith and our commitment, seldom made explicit, even more seldom challenged, that knowledge is a good in itself, knowledge and such power as must come with it.

One will perhaps think back to the early days of physical science in western culture when it was felt as so deep a threat to the whole Christian world. One will remember the more recent times of the last century where such a threat was seen by some in the new understanding of the relations between man and the rest of the living world. One may even remember the concern among the learned at some of the developments of physics, the theory of relativity, even more the ideas of complentarity, and their far-reaching implications

on the relations of common sense and of scientific discovery, their enforced reminder, familiar to Hindu culture but rather foreign to that of Europe, of the latent inadequacies of human conceptions to the real world they must describe. One may think of these things, and especially of the great conflicts of the renaissance, because they reflect the truth that science is a part of the world of men; that often before it has injected into that world elements of instability and change; that if there is peril in the situation today, as I believe, we may look to the past for reassurance that our faith in the value of knowledge can prevail.

An atomic bomb is not a new conception, a new discovery of reality: it is a very ordinary thing in some ways, compact with much of the science that makes our laboratories and our industry. But it will change men's lives as over the centuries the knowledge of the solar system changed them; for in a world of atomic weapons wars will cease. And that is not a small thing, not small in itself, as the world knows today perhaps more bitterly than ever before, but perhaps in the end even greater in the alterations, the radical if slow alterations, in the relations between men and between nations and cultures, that it implies.

It can only help us, I believe, to recognize these issues as rather great issues. We can serve neither ourselves, nor the cause of the freedom and growth of science, nor our fellow men, if we underestimate the difficulties, or if we through cowardice becloud the radical character of the conflict and its issue. During our lifetime perhaps atomic weapons could be either a great or a small trouble. They cannot be a small hope. They can be a great one.

Sometimes, when men speak of the great hope and the great promise of the field of atomic energy, they speak, not of peace, but of atomic power and of nuclear radiations. Certainly these are proper enthusiasms, enthusiasms that we must all share. The technical feasibility of deriving virtually unlimited amounts of power from controlled nuclear reactors seems nearly certain, and realization of plants to demonstrate the advantages and limitations of such power does not seem, from the point of view of technical effort, remote. One must look at history to learn that such possibilities will in time be found of value, will in time come to play an important, even if at this moment not thoroughly understood, part in our industry and economy. You have heard this morning of some of the biological and medical problems and uses of radiation from such reactors. Even physicists can think of some instructive things to do with the grams of neutrons such reactors make available. And all of us, who have seen something of the growth of science, know very well that what we can discern of the possibilities in these fields is a very small part of what will turn up when we get into them.

Nevertheless, it would seem somewhat wrong to me to let our confidence—in my view our wholly justified confidence—in the future of the peaceful applications of nuclear physics distract us entirely from the immediacy, and the peril, of atomic weapons. It would not be honest to do so, for not even a better understanding of the physical world, not even the most welcome developments of therapy, should make us content to see these weapons turned to the devastation of the earth. It will not even be very practical to do so. Technically, the operation of reactors and the manufacture of weapons are rather closely related. Wherever reactors are in operation there is a potential source, not necessarily a convenient one, of materials for weapons; wherever materials are made for weapons they can be used for reactors that may be well suited to research or power development. And it would seem to me almost inevitable that in a world committed to atomic armament the shadows of fear, secrecy, constraint, and guilt would hang heavily over much of nuclear physics, much of science. Scientists in this country have been quick to sense this and to attempt to escape it. I do not think that this attempt can be very successful in a world of atomic armament.

There is another set of arguments whose intent is to minimize the impact of atomic weapons, and thus to delay or to avert the inevitably in the end radical changes in the world which their advent would seem to require. There are people who say they are not such very bad weapons. Before the New Mexico test we sometimes said that too, writing down square miles and equivalent tonnages and looking at the pictures of a ravaged Europe. After the test we did not say it any more. Some of you will have seen photographs of the Nagasaki strike, seen the great steel girders of factories twisted and wrecked; some of you may have noticed that these factories that were wrecked were miles apart. Some of you will have seen pictures of the people who were burned, or had a look at the wastes of Hiroshima. That bomb at Nagasaki would have taken out ten square miles, or a bit

more, if there had been ten square miles to take out. Because it is known that the project cost us two billion dollars, and we dropped just two bombs, it is easy to think that they must be very expensive. But for any serious undertaking in atomic armament—and without any elements of technical novelty whatever, just doing things that have already been done—that estimate of cost would be high by something like a factor of a thousand. Atomic weapons, even with what we know today, can be cheap. Even with what we know how to do today, without any of the new things, the little things and the radical things, atomic armament will not break the economic back of any people that want it.

The pattern of the use of atomic weapons was set at Hiroshima. They are weapons of aggression, of surprise, and of terror. If they are ever used again it may well be by the thousands, or perhaps by tens of thousands; their method of delivery may well be different and may reflect new possibilities of interception, and the strategy of their use may well be different from what it was against an essentially defeated enemy. But it is a weapon for aggressors, and the elements of surprise and of terror are as intrinsic to it as are the fissionable nuclei.

One of our colleagues, a man most deeply committed to the welfare and growth of science, advised me not long ago not to give too much weight in any public words to the terrors of atomic weapons as they are and as they can be. He knows as well as any of us how much more terrible they can be made. "It might cause a reaction," he said, "hostile to science. It might turn people away from science." He is not such an old man, and I think it will make little difference to him, or to any of us, what is said now about atomic weapons if before we die we live to see a war in which they are used. I think that it will not help to avert such a war if we try to rub the edges off this new terror that we have helped bring to the world. I think that it is for us among all men, for us as scientists perhaps in greater measure because it is our tradition to recognize and to accept the strange and the new, I think it is for us to accept as fact this new terror, and to accept with it the necessity for those transformations in the world which will make it possible to integrate these developments into human life. I think we cannot in the long term protect science against this threat to its spirit and this reproach to its issue unless we recognize the threat and the reproach and help our fellow men in every way suitable to remove their cause. Their cause is war.

If I return so insistently to the magnitude of the peril, not only to science, but to our civilization, it is because I see in that our one great hope. As a further argument against war, like arguments that have always existed, that have grown with the gradual growth of modern technology, it is not unique; as a further matter requiring international consideration, like all other matters that so require it, it is not unique. But as a vast threat, and a new one, to all the peoples of the earth, by its novelty, its terror, its strangely promethean quality, it has become, in the eyes of many of us, an opportunity unique and challenging.

It has proven most difficult to make those changes in the relations between nations and peoples, those concurrent and mutually dependent changes in law, in spirit, in customs, in conceptions—and they are all essential and no one of them is absolutely prior to the others—that should make an end to war. It has not only been difficult; it has been impossible. It will be difficult in the days ahead, difficult and beset with discouragements and frustrations, and it will be slow. But it will not be impossible. If it is recognized, as I think it should be recognized, that this, for us, in our time, is the fundamental problem of human society, that it is a precondition not only for civilized life, or for freedom, but for the attainment of any living human aspiration, then it will not be impossible. These are very major commitments, nor would I minimize their depth. For they involve holding prior to all else we cherish—all that we would live for and die for—our common bond with all peoples everywhere, our common responsibility for a world without war, our common confidence that in a world thus united the things that we cherish—learning and freedom and humanity—will not be lost.

These words may seem visionary, but they are not meant so. It is a practical thing to avert an atomic war. It is a practical thing to recognize the fraternity of the peoples of the world. It is a practical thing to recognize as a common responsibility, wholly incapable of unilateral solution, the completely common peril that atomic weapons constitute for the world, to recognize that only by a community of responsibility is there any hope of meeting the peril. It could be an eminently practical thing to attempt to develop these arrangements and that spirit of confidence between peoples that are needed for the control of atomic

weapons. It could be practical to regard this as a pilot plant for all those other necessary international arrangements without which there will be no peace. For this is a new field, less fettered than most with vested interest or with the vast inertia of centuries of purely national sovereignty; this is a new field, growing out of a science inspired by the highest ideals of international fraternity.

It would seem somewhat visionary and more than a little dangerous to hope that work on atomic energy and atomic weapons might proceed as have so many things in the past, like the building of battleships, on a purely and narrowly national authority, without basic confidence between peoples, without cooperation or the abrogation in any way of sovereignty, and to hope that with such a course an armament race would not develop, that somehow these separate, distrustful atomic arsenals would make for the peace of the world. It would seem to me visionary in the extreme, and not practical, to hope that methods which have so sadly failed to avert war in the past will succeed in the face of this far graver peril.

It would in my opinion be most dangerous to regard, in these shattering times, a radical solution as less practical than a conventional one. It would also be most dangerous, and most certain to lead to tragic discouragements, to expect that a radical solution can evolve rapidly, or that its evolution will be free of the gravest conflicts and uncertainties. The first steps in implementing the internationalization of responsibility—of responsibility perhaps in the first instance for averting the perils of an atomic war—will inevitably be very modest. It is surely not proper for me, who have neither experience nor knowledge, to speak of what such steps might be. But there are two things that perhaps might be borne in mind that we might wish to say as scientists. One is that, not only politically but technically, this field of atomic energy is a very new field and a very rapidly changing one, and that it would be well to stress the interim, tentative character of any arrangements that might in the near future seem appropriate. The second is that in the encouragement and cultivation of the exchange between nations of scientists and students we would see, not only an opportunity for strengthening the fraternity between scientists of different lands, but a valuable aid in establishing confidence among the nations as to their interests and activities in science generally, and in the fields bearing on atomic energy in particular. It is not at all as a species of super-intelligence that we should propose this; it is rather as a concrete and constructive, if limited, form of those relations of cooperation among nations which must be the hope of the future. Let me say again: these remarks are not intended in any way to define or exhaust the content of any international arrangements it may be possible or appropriate to make, nor to limit them; they are offered as suggestions that occur naturally to a scientist who would wish to be helpful, but they leave quite untouched the basic problems of statesmanship on which all else depends.

There will have been little in these words that can have been new to anyone. For months now there has been among scientists, as well as many others, a concrete, often a most confusingly articulate concern, both for the critical situation in which nuclear physics finds itself and for the more general dangers of atomic war. It seems to me that these reactions among scientists, that have caused them to meet and speak and testify and write and wrangle without remission, and that are general almost to the point of universality, reflect, correctly reflect, an awareness of unparalleled crisis. It is a crisis because, not only the preferences and tastes of scientists are in jeopardy, but the substance of their faith: the general recognition of the value, the unqualified value, of knowledge, of scientific power and progress. Whatever the individual motivation and belief of the scientist, without that recognition from his fellow men of the value of his work, in the long term science will perish. I do not believe that it will be possible to transcend the present crisis in a world in which the works of science are being used, and are being knowingly used, for ends men hold evil; in such a world it will be of little help to try to protect the scientist from restraints, from controls, from an imposed secrecy, which he rightly finds incompatible with all he has learned to believe and cherish. Therefore, it has seemed necessary to me to explore somewhat the impact of the advent of atomic weapons on our fellow men, and the courses that might lie open for averting the disaster that they invite. I think there is only one such course, and that in it lies the hope of all our futures.

HEALTH PROTECTION ACTIVITIES OF THE PLUTONIUM PROJECT[1]

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Associate Project Director for Health, Metallurgical Project

(Read November 16, 1945, in the Symposium on Atomic Energy and its Implications)

WHEN the scientists of America became reasonably certain that they could produce a nuclear chain reacting pile, they were brought face to face with the hazards of such an undertaking. It was realized before any pile was in operation that the amounts of radioactive material produced by the fission of uranium in a relatively small system would be equivalent to hundreds or even thousands of grams of radium. It was also realized that when a chain reacting system would operate it would give off terrifically intense gamma rays and neutrons which were known to be more hazardous than gamma radiation. It was calculated that, if uranium slugs were to be removed from the pile, some with activities equivalent to hundreds of curies would have to be handled.

Because of these dangers, some of the scientists doubted whether the program could or should be prosecuted. In the War Department sponsored releases W. L. Lawrence makes the rather exaggerated statement that, "The atomic pile therefore created the greatest problem for protecting human life mankind ever faced." A. H. Compton, who was head of the Metallurgical Project, considered it expedient, therefore, to have a Health Division organized in connection with the project along with the Chemistry, Physics, and Technical Divisions. The Director of the Health Division was given a place on the Laboratory and Project Councils so that he might know exactly what was being considered, what was being done, and advise on the necessary health protective measures before rather than after the necessity for health protection arose.

The Health Division was organized into three separate lines of activity.

1. *The Medical sections* had to do with all those functions where personnel were observed directly or by means of clinical laboratory tests.
2. *The Health-Physics sections* were concerned with the means of measuring the quantity and quality of radiations that were present in the various areas and that the individual people received. They were also concerned with plant and laboratory design so as to see that the necessary protective measures were built in.
3. *The Biological Research sections'* duties were to make a coordinated study of the effects of alpha, beta, gamma, and neutron rays on the body, whether they came from external sources or followed the ingestion, inhalation, or transcutaneous assimilation of fission products, plutonium, and uranium.

The research, development, and organizational work herewith reported is that of a large group of scientists at many institutions, organized for a joint effort under the Metallurgical (Plutonium) Project by A. H. Comptom as Project Director, with headquarters at the University of Chicago, and Robert S. Stone, as Associate Project Director for Health, with headquarters first at the University of Chicago and later at Clinton Laboratories.

It would take much space to list all of those who have participated in the work, and hence only the leaders will be mentioned.

Medical Activities: S. T. Cantril, first at the University of Chicago, next at Clinton Laboratories, Oak Ridge, Tennessee, and finally at Hanford Engineer Works, Richland, Washington; L. O. Jacobson at the University of Chicago; John E. Wirth at Clinton Laboratories; J. J. Nickson at the University of Chicago; and E. R. Miller at the University of California.

Biological Activities: K. S. Cole, C. L. Prosser, A. M. Brues, Wm. Bloom and E. G. Barron at the University of Chicago; Howard J. Curtis, R. E. Zirkle, and Paul S. Henshaw at Clinton Laboratories; J. G. Hamilton at the University of California Radiation Laboratory; E. Lorenz at the National Cancer Institute; A. Tannenbaum at Michael Reese Hospital in Chicago.

[1] Released with the approval of the Directors of the Laboratories concerned.

[2] Professor of Radiology, University of California Medical School (on leave): Visiting Professor of Roentgenology, University of Chicago; Health Division of Monsanto Chemical Company Clinton Laboratories.

Health-Physics Activities: E. O. Wollan, J. E. Rose at the University of Chicago; H. M. Parker, first at the University of Chicago, then at Clinton Laboratories and later at Hanford Engineer Works; and K. Z. Morgan at Clinton Laboratories.

Special Clinical Research: Lloyd B. Craver at Memorial Hospital in New York City; B. V. A. LowBeer at the University of California Hospital in San Francisco.

THE MEDICAL SECTIONS

The Medical sections performed all of the usual functions of the good industrial medical departments such as: preemployment physical examinations, x-ray examinations of the chest, routine urine and blood examinations, and periodic reexaminations. The peculiar purpose of this group, however, was to put particular emphasis on those findings which might indicate harmful effects coming from radiations. Since the hands are the part of the body that usually gets most exposure to radioactive materials being manipulated in a laboratory, special studies of the skin of the hands were instituted, bearing in mind the changes that have been known to occur in the hands of workers with radium and x-rays. On the whole these studies have resulted in revealing no significant change to date in the hands of employees on the Plutonium Project. One must bear in mind, however, that such skin changes may not appear for five, ten, or even fifteen years.

At the beginning of the Project the blood count was considered by most radiologists and by the National Advisory Boards on x-ray and radium protection to be the most significant index of overexposure of the whole body to radiation. A study of the literature revealed, however, that very few accurate studies of large groups of normal people had ever been undertaken and also that the normal variations in the blood counts of any individual were so great that minor fluctuations could not be considered significant. Blood counts have been taken at regular intervals on all of the personnel exposed to radiations on the project and for control purposes on a great many of those not exposed. It has been the good fortune of the Project to keep radiation exposures within the range of that considered tolerable, and the blood counts have revealed no significant changes. A statistical analysis of the blood counts of the whole group may yet bring out some significant trends. Clinical studies using doses of x-rays from 100 to 200 times tolerance, as well as studies on animals, lead us to believe that so far as individuals are concerned the blood count is of very little value in detecting early changes due to overexposure. Let me hasten to add that, since no better test has yet been found, it has been felt necessary to continue doing blood counts.

In view of the results of studies of blood counts, it was considered necessary to search for some other clinical test which might give an indication of incipient changes from low level radiation exposures. Since the basic mechanism of the action of radiation is not known, empirical approaches had to be used. It was known that abnormal porphyrin metabolism was connected with certain toxic conditions. Hence, disturbances of the red blood cell protoporphyrin and the urinary coproporphyrin in exposed personnel and animals was sought. These investigations have revealed some changes but they cannot be associated yet with any specific cause. It was known that definite overexposure to radiation caused some change in the white blood cells and that these changes were associated with phosphorus and nucleic acid metabolism. Hence studies along these lines were instituted in the hope that slight metabolic changes could be detected. While the studies have shown that changes can be detected after exposures of several roentgens, they have not yet been found to be of value in the borderline type of case of near-tolerance exposure.

Since the liver has long been called the detoxifying center of the body, it seemed likely that the liver function might be disturbed by either radiations or chemically toxic agents. The only question was whether the disturbances would be detectable at levels of exposure near to that considered to be tolerable. The liver function has been investigated by the serum colloidal gold method, by the cephalin cholesterol method, and by following the urine urobilinogen, in addition to other procedures. While some changes have been found they have not yet been satisfactorily linked to small doses of specific chemical or radiation toxins.

Methods for studying urinary pigments have recently been developed, particularly the one known as urorosein. These techniques have been improved and utilized on the Project and it has been found that in general urinary pigments are increased in people exposed to chemical and radiation hazards, but here again it has not been possible as yet to associate the specific change with specific cause.

The Medical section was formed of people familiar with radiation exposures and they expected this to be the major problem. It was soon evident, however, that long before there would be any significant amount of radiation present there would be a large amount of uranium to be handled. The literature available at the beginning of the Project indicated that uranium was an extremely toxic substance once it got entrance into the body. To handle it in the tons that would be necessary would apparently require very extreme protective measures. The fact that the workers at the Port Hope factory in Canada, where radium had been extracted for years from tons of uranium ores, had not shown any demonstrable trouble from the uranium gave encouragement to the belief that uranium was not as toxic as it was reported to be. This encouragement was still further borne out when mice placed in one of the Project laboratories where uranium oxide dust was extremely thick were found to develop into more healthy mice than controls in the animal farm. Since then a great deal of work has been done on uranium toxicity by skilled toxicologists. It has been found that if uranium succeeds in getting into the blood it is a toxic substance, but that many of the compounds are difficult to get through the lung or intestines, and that on the whole its hazard can be satisfactorily controlled. A considerable amount of experimentation has been done to study the long term effects of uranium, the results of which to date would seem to indicate that in general, unless there is an acute reaction from an acute overexposure, there is not likely to be any serious chronic damage.

That uranium in fused sodium fluoride would fluoresce when exposed to ultra-violet light has long been known. Using this fact a method was developed to detect as little as one-hundred billionth of a gram of uranium. It was designed for use with urine of exposed personnel. It was found that the amount of uranium excreted in the urine was closely associated with the degree of exposure of the individual to uranium dusts but not with his clinical state. Exposures also caused change in the red blood cell protoporphyrin values and in the urine excretion of coproporphyrin, but these were not specific findings since they occurred in other conditions and with exposure to other metals.

The advent of plutonium into the world brought a new problem. Of course, at the beginning of the Project, plutonium existed only in micro quantities and, therefore, was no hazard. As the cyclotron production rose to hundreds of micrograms, and later the Clinton pile production rose to grams, the possible hazard of this material became a more serious problem. It was found that from the point of view of acute effects it was just as hazardous microgram for microgram as radium. Since it has no radioactive gaseous daughter, like radon, the problem of protection became one of protecting against dusts and vapors. The fact that micrograms were hazardous made it necessary to be able to detect very small quantities in the body; quantities so small that it would be difficult or impossible to quantitate them by chemical methods. However, plutonium is an alpha emitter and this radiation can be used to measure minute amounts. It has been found that people excrete it in their urine to the extent of between .005 and .01 per cent per day of the amount deposited in the body. A laboratory procedure has, therefore, been developed for detecting such small amounts of plutonium in urine.

Thus, the level of plutonium in the body of each worker can be determined, and future exposure of those who may have acquired a tolerance dose can be stopped.

THE HEALTH-PHYSICS SECTION

The term "Health-Physics" has been used on the Plutonium Project to define that field in which physical methods are used to determine the existence of hazards to the health of personnel. It is not enough simply to know that radiations are present in a given area, but the instrument reading must be interpretable in the light of damage that might be done by such radiations to living animals. The physicians and the biologists can determine what changes occur, but the physicists must define the characteristics of the physical situation where and when such biological changes occurred.

Before the war such hazards as existed were relatively easily controlled. The most wide-spread ones existed in those locations where x-rays and radium were used for medical purposes. In most cases the radiation sources were fixed and protection was built-in. There were a few industrial radiographic installations using radium or x-rays, usually with built-in protection. However, it must be remembered that owing to a lack of knowledge of how to measure radiations, as well as to a lack of understanding of their action on the human body, many hundreds of physicists, physicians, manufacturers, and laborers were damaged by

x-rays and radium gamma rays in the first few years of their use. Even at the time of the last war many radiologists and radium dial painters were severely damaged and some deaths resulted. Just before the present war the problem was beginning to enlarge because of the increasing numbers of cyclotrons and other pieces of apparatus using high energy particles with the production of radioactive materials. The advent of the nuclear chain reacting piles and the chemical separations plants for separating plutonium from fission products has expanded the problems of radiation protection, and hence radiation measurement, beyond all previous estimates.

In 1942, when the Health-Physics section was organized, there was still no pile. There were no accumulations of extremely radioactive fission products and so the first problems were those of calculating the shielding that would be necessary if the levels of radiation intensity which the pile physicists calculated would exist in the pile turned out to be correct. It was not a simple matter of applying absorption data to given circumstances because a great deal was not known about the behavior of neutrons of various energies. Moreover, it was not a simple problem of calculating the needed thickness of concrete walls because there had to be holes in the walls through which uranium could be loaded and unloaded. In some places concrete was not satisfactory for various reasons and so composite shields had to be devised and tested. In the chemical extraction plants it was going to be necessary to have the tops of cells open at times when they contained extremely active fission products in large quantities. The skyshine, or radiation reflected down by the air, assumed a new importance.

Neutrinos might theoretically be present in great numbers and therefore the question was raised, if neutrinos exist and come through the shield, will they be a medical hazard? During the project, the question of whether mesotrons were originating in the pile was raised. These new radiations with no known means of measuring them added to the problems of the health physicist.

It was realized that with a new industry working in unexplored fields with new equipment it would probably be impossible to keep all sources of radiation behind sufficient shielding. Analytic samples would have to be procured for laboratory testing and even one drop of some solutions was a hazard. It was already known that in laboratories where the individualistic scientists perform their experimentation it would be impossible to keep all sources of radiations under control. Hence, it was necessary to set up personnel monitoring such that some measurement of the amount of radiation reaching each individual could be made. There were on the market at the time of the beginning of this project a few small ionization chambers that were shaped like fountain pens and could be worn in the pocket. Any decrease in the charge placed on these instruments, read on a special electroscope, indicated the total amount of ionization that had occurred from the time of charging until the time of reading. This decrease was calibrated in terms of roentgens. These instruments are satisfactory for measuring x-rays with an energy of about 200 kv but the calibration is not entirely accurate for gamma rays and only very energetic beta rays can penetrate its walls. The manufacturer of these instruments rapidly expanded his facilities so that meters of this kind were made available. A great deal of difficulty was found with them—the principle was simple enough but the application was somewhat complicated. High humidity, rough handling, and poor construction all tended to cause leaks or complete discharge. One big advantage was that these meters always tended to read higher than they should for the exposure received. There were no errors in the low direction. It was found by experience that, if each person wore two of these instruments, the lower reading of the two was a fairly correct measure of the radiation that penetrated the instruments. However, these instruments were useless for quantitative measurement of beta rays, weak x-rays, and neutrons. Better pocket ionization chambers and better complete pocket electroscopes were developed but did not reach the large production stage. When one realizes that at Clinton Laboratories several thousand of these instruments were required to keep all shifts supplied with good working ones, and that more than a thousand readings were made each day, the pocket meter problem assumes its true proportions.

The photographic film method of registering exposure to radiations has long been used. Films have varying responses to rays of different energies and therefore are impossible to calibrate for rays of all energies and types. By covering all the film except a small area with a thin shield of metal, it was possible to balance the low penetration of the weak radiations against the low photographic effects of the more penetrating radiations. The small unshielded area, or window, allowed those

beta rays that were energetic enough to pass through the paper envelope, to affect the film. After many trials a reasonably satisfactory film meter was evolved. The films had the advantage of not being affected by wet weather or by rough handling. These films thus acted as a good check against the pocket ionization meters, and those who were routinely exposed had to carry both kinds of meters. Others who were only occasionally exposed might be given either one or the other type. From the readings of these meters it is now known that no one on the Plutonium Project received any serious total-body overexposure and the number of slight overexposures was very limited.

Of course, one of the dangers of handling radioactive materials is that hands will go much closer than the body and thereby receive large overexposures which are not registered on meters attached to the body of a person. To overcome this, film meters were devised that could be worn on the fingers, hands, or wrists so as to register the amount of radiation received. Such meters, even when made of the smallest possible dimensions, were a handicap to the individuals' activities and consequently were worn only at intervals to test the efficiency of the individual in avoiding overexposure.

Since hands become contaminated with radioactive materials even when wearing rubber gloves while handling them, and shoes may get contaminated from activity reaching the floor, special apparatus had to be developed for rapidly measuring hands and shoes in such a way as to indicate whether dangerous amounts of material were present. Geiger-Mueller counters, scaling circuits, and registers were used in such a way that the fronts and backs of both hands and the soles of the feet were placed in a fixed geometry and counted for an automatically controlled time.

As a means of checking on the personnel monitoring and of watching out for unexpected circumstances, the work areas were nearly all quite well monitored at fixed locations. Many of these monitoring instruments worked on recorders so that the intensity of radiation at any spot was being recorded continuously or the total number of roentgens received in any eight hours was recorded. In addition to ionization chambers, Geiger-Mueller counters and proportional counters were used in the work area monitoring, and some warning instruments were placed to detect people with contaminated clothes.

Since it was impossible to have fixed monitoring at all points in all buildings, routine surveys of benches, desks, floors, sinks, hoods, etc., were necessary. A group of people had to be specially trained for this job of surveying. Instruments were developed for measuring the alpha radiation from surfaces, the beta and gamma radiations, and the radioactive materials in the air. Survey instruments of these kinds had not been needed on any such scale before and hence had to be developed before they could be used. This in itself was a tremendous problem. If anyone should wonder how contamination could get around to such an extent as to indicate a need for such surveys, let him think how small a droplet of a saturated solution of radium chloride it would take to contaminate a whole laboratory, and then imagine working with beakers, tubs, and vats full of a similar material.

Since the laboratory clothes of the people working with radioactive materials became contaminated from time to time with these materials, it was necessary to set up a special laundry in which methods of decontaminating these clothes were developed and used. Instruments were devised for measuring the alpha, beta, and gamma radiations that might be coming from the clothing both before and after the laundering process.

Part of the duty of the Health Division, as mentioned before, was to make sure that the public at large was not being damaged by the operations in the plant. In order to take care of this, the atmosphere for miles around had to be monitored, the waste waters had to be checked, and the background level of radioactivity checked in nearby inhabited areas, as well as on the grounds of the various laboratories and plants.

The atmospheric monitoring apparatus was at first done with ionization chambers equipped for measuring gamma radiation. Later some chambers which would measure beta rays were installed, and still later thin-walled Geiger-Mueller counters were utilized. By these means it has been shown that the gases and vapors discharged from stacks and laboratories established at Clinton, Chicago, and Hanford have not created any hazards because of radiation or chemical properties.

The highly contaminated waste products from the chemical separation of plutonium from fission products and uranium were sent to underground storage tanks, but large quantities of water containing proportionately very small amounts of radioactive materials were disposed of to the usual channels of waste disposal, namely rivers. It was

necessary, of course, to see that the total amount of radioactive materials was such that the rivers in the various districts were not made hazardous. Counters were developed which could be immersed in the water so that the gamma radiation could be measured directly. The amount of beta radiation in materials was checked by evaporating known quantities of water to dryness and counting the residue on regular counters. In some instances water-retaining basins were used which allowed the short half-life radioactive materials to decay before the water was finally released.

Among the first products that are given off in the chemical process are radio-xenon, radio-iodine and radio-ruthenium. Xenon is a noble gas and forms no compounds. It must be disposed of as a gas. Iodine is a very volatile compound and in the chemical process comes off as a vapor. Ruthenium is volatile in some of its compounds. Thus a problem in the disposal of the radioactive gases and vapors was one of the many that had to be faced. Dilution in the air was the only solution for the xenon problem and the easiest for the other two and many other materials that came off in relatively small amounts. It was found that very little was known of weather conditions in the immediate vicinity of any given area and that extremely little was known in a practical way about how gases dispersed when leaving stacks of varying heights under varying conditions of wind, temperature, and moisture. Hence meteorological studies of the conditions at the Clinton and Hanford plant sites had to be undertaken, and studies made of dispersion of radioactive gases. The results of these showed that sufficiently satisfactory conditions of the weather could be predicted to allow safe operation of the plants in so far as sufficient dilution of the radio-elements was concerned.

The instrument development problems that faced the Health-Physics section were numerous and were not all solved because it was felt that, since the radiations in working areas could with reasonable assurance be kept down to low levels, the talents of those capable of developing such instruments would be better applied to instruments for the operation and control of piles and chemical extraction plants. The Lauritsen electroscope was the only satisfactory survey instrument at the commencement of the project and is still one of the best. No commercially made electronics type of survey instrument has been wholly satisfactory. Hence, practically all instruments had to be developed and made within the project. The measurement of fast, slow, and thermal neutrons and of alpha radiations, in terms that indicate their effectiveness on living tissue, is still in the development stage. Few if any of the instruments so far devised have proved to be rugged enough to stand up under long-distance transportation or rough usage. Hence, considerable improvement is still possible in most of them.

Lest anyone should think that the radiation conditions in any given area, such as near piles with heavy shielding, can remain stationary, let him remember that instruments, or any material, removed from the pile for purposes of study or repair are extremely radioactive because of the high neutron flux to which they have been subjected. The simplest internal adjustments are often complicated by the radioactivity. The leakage of even air from the interior of a pile to working areas brings with it serious hazards. At the chemical extraction plants one small drop of a very highly radioactive solution can create a health hazard throughout an entire building.

The Health-Physics section had a tremendous burden not only of instrument development and use but also of organizing so as to be sure that proper records were kept on the exposures of all individuals and on the levels of radiation in all parts of the plants, in the air, and in the water.

Since the health-physicist is the person best acquainted with the behavior of the radiations and of the personnel handling them, he has been in an advantageous position to give advice on remote control instruments and equipment for use in the laboratory. Similarly, he has the most accurate knowledge of the shielding necessary to protect against given amounts of known radiations. It was frequently very important to the successful carrying out of an operation to have as thin a shield as possible. Clumsy, heavy shields can protect against almost any radiation, but for efficiency only that amount of shielding which is really needed should be used.

The personnel of the Plutonium Project owe a great debt of thanks to the men of the Health-Physics groups who have protected them from hazards and from their own carelessness.

BIOLOGICAL RESEARCH

When the Health Division of the Plutonium Project was called into existence in 1942, there were established tolerance doses, or maximum permissible exposures, for x- and gamma rays, but it was evident that these rested on rather poor ex-

perimental evidence. There was little knowledge of the tolerance for fast neutrons, and none for slow and thermal neutrons, or for alpha or beta rays. Except for radiophosphorus and radiostrontium, nothing was known of tolerance of artificial radioactive materials in the body and the knowledge of these two was sparse. Comparatively little was known even about radium which had caused considerable havoc among radium dial painters. Consequently, while the hazards were being estimated, experiments were started to check the calculations and to determine the behavior in the body of the multitudinous radioactive isotopes that were to be created.

In 1942 it was considered conceivable that something might happen to a chain reacting pile that would result in a spread of radioactive materials over a considerable area. It was also thought possible that the enemy might use radioactive materials from such chain reacting piles as he might possess as a means of contamination to render areas uninhabitable for military purposes. Wigner and Smyth calculated that "fission products produced in one day's run of a 100,000 kw chain reacting pile might be sufficient to make a large area uninhabitable." Consequently, it was very desirable to study the metabolism and the radiation effects of the various fission products so as to be prepared for any catastrophe either in our own plants or because of enemy activities. In addition, it was felt wise to make some studies on how radioactive materials might be removed from the body and how people who might be overexposed to radiations in any form might be so treated as to give them the best possible chance for survival.

The first experiments were set up to test the validity of the x-ray and gamma-ray tolerance doses. In general we can now state that the one-tenth of a roentgen has no greater factor of safety than ten, and that further studies might reveal that even this factor is too large. The tolerance dose for fast neutrons was set at one one-hundredth of a neutron unit "*n*." This is equivalent to 0.025 roentgens if by roentgen we mean a specified amount of ionization per gram of tissue. We have called this unit a "rep" (roentgen equivalent physical). Experiments to date have tended to show that the *x* to *n* ratio varies a little with animal species and with materials picked for the test but that it varies between 5 and 8 for effects on the whole body of mammals. Hence the original specification for the fast neutron tolerance had only a slightly greater factor of safety than the tolerance for x-rays. It has also been determined that the nature of changes within the body are almost identical for x-rays and fast neutrons of comparable amounts and that there is a total additivity of these radiations in producing given effects. This means, of course, that in protecting personnel it is not possible to take a tolerance dose of x-ray and a tolerance dose of fast neutrons on the same day.

Slow neutrons were considered to exercise their effect largely by the gamma ray emitted from the capture of a neutron by hydrogen. Experimental work has shown that this is not true but that only about one-quarter of the effect in small animals can be attributed to this gamma radiation, and about one-half the effect in man might be attributed to it. The larger proportion of the remaining effect comes from the nuclear and proton recoil when nitrogen is transmuted to carbon. A small part of the effect is due to the activation of phosphorous, sodium, potassium, chlorine, and other constituents of the body. Chronic experiments are not yet finished so that an exact slow neutron tolerance has not been established. The question of the additivity of the effects of slow neutrons and gamma rays has not been clearly established, but from the type of effect it seems likely that there will be almost complete additivity.

Beta ray tolerance is largely a question of skin tolerances to beta rays, and this is extremely difficult to establish since animal skins differ so much from human skins. However, it has been established that single large doses of beta rays and multiple small doses can cause cancers in the skin without the animal being killed by the effect of the beta rays. Previous experience had of course shown that beta rays from the radium decay products could cause cancer in human skin, but in these instances only local areas were exposed to the radiation. Since the beta rays exert their effects on the surface of animals, it was to be anticipated that there would not be a total additivity so far as the lethal effects on the animal were concerned, and this has been found to be the case. Time has not permitted an investigation of the problem of the additivity of the skin effects of beta and gamma rays.

The fission products as is well known consist of isotopes of about thirty of the known elements occurring in the middle of the periodic table. These usually decay by beta emission with some accompanying gamma radiation. Many of them

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are elements that have not been used in biology and medicine to any extent and therefore little was known about their behavior.

The first studies undertaken were on small tracer amounts made on the cyclotron before chain reacting piles were in operation. There is altogether too large and complex a body of knowledge about the metabolism of these products to make it possible even to scratch the surface in this short presentation, but the following few facts will be of interest. Strontium, barium, tellurium, cerium, and iodine can all enter the body by absorption from the gastro-intestinal tract. These and many others enter quite readily through the lungs, the amount entering depending upon the chemical compound in which they are found. Strontium, barium, zirconium, yttrium, and others locate quite selectively in the bones, and many of them stay for long periods of time. Lanthanum, cerium, and tellurium show no significant degree of selective localization in any tissue and are rather rapidly eliminated. That iodine is selectively absorbed by the thyroid was known before the war. The lungs retain some of the inhaled radioactive elements for considerable periods of time and thus are exposed to the radiations even if they are only weak beta radiations. The human lung retains a considerably larger per cent of inhaled small particles than do the lungs of rats and other small animals.

While it has been possible to study the metabolism of all of the important members of the fission products, it has not been possible nor so necessary to study the radiation effects from all of these isotopes. Thus it has been possible to study in some detail the acute and chronic effects of strontium as a beta ray emitting substance localizing in the bones; of radium and plutonium as alpha emitting elements that locate in the bones; of phosphorous as a beta emitting particle on the skin; of yttrium as an unabsorbed beta emitting element in the gastro-intestinal tract, and of cerium as a beta emitting particle in the lung. Plutonium is being used as an alpha emitting particle for these various organs. It will be less of a jump to extrapolate from the facts accumulated from these studies to other conditions than it was from external radiations to radiations being emitted in localized areas inside the body.

It is now well established that strontium given to mice and rats in amounts insufficient to kill them for many months can cause bone and lymphatic tissue tumors to develop in significant numbers of animals. From the facts accumulated regarding the acutely lethal effects of fission products in the body it can be estimated by extrapolation that man would be killed by about 10 microcuries per gram of body weight.

In an attempt to get from acute and sub-acute effects to tolerance levels, it has been shown that comparisons with external radiations might be used. For instance, it takes 25 *r* of total body radiation with x-rays to produce minimum detectable effects on the blood picture of rats, mice, and rabbits. A similar effect is noted after .5 microcuries of strontium per gram of animal. Assuming that the ratio between this effect and the tolerance amount is the same for strontium and x-rays, it is evident that 0.002 microcuries per gram or 140 microcuries per 70 kilogram man would be the tolerance limit.

As has been mentioned above, plutonium was not available in the early days of the project, but on the basis of its alpha activity and long half-life it was estimated that it would be about one-fiftieth as dangerous as radium. For acute effects this has been shown to be wrong, and the fact was determined that one microgram of plutonium was about as dangerous as one microgram of radium. The reason for this discrepancy apparently lies in the different distribution of the plutonium within the bone. The radioautographic technique which has been developed on the project, but was not new to the project, has been very successful in the demonstration of these organ distributions. It has also been found that plutonium locates in the liver and may cause severe liver damage. Over long periods of time plutonium has been shown to cause atrophy of the bone and bone sarcomas. The tolerance amount, or maximum permissible dose, in the human has been estimated to be one microgram. Since once the material is located in the body it remains there, this low tolerance amount becomes extremely important. For the sake of workers staying in this field it is hoped that further biological data, as obtained, will permit a raising of this low level.

Another activity of the Biological Research groups has been the attempt to discover means of causing an increased rate of elimination of the fission products and plutonium from the body. Such efforts have not been successful to date although it has been possible to relocate some of the plutonium in other parts of the bones where it may be less damaging. Another activity that has yielded largely negative results so far has been

that of attempting to find a method of treating animals which have been overexposed. One reason for this failure has been that the fundamental mechanism of the action of radiation on living tissues has not been understood. All methods of treatment have therefore been symptomatic rather than specific. For this reason studies into the fundamental nature of the action of radiations have been carried on to some extent, the limitation being that it was unlikely that significant results could be obtained during the period of war. However, some progress has been made and it is now known that a probable point of action is on the enzymes containing the sulfhydryl radical. Through this, some method of approaching a means of detecting incipient changes may be reached.

In a brief report of the work of many people it is not possible even to mention a lot of the work that has been done. Much of it using physiological, biochemical, and histo-pathological methods does not lend itself to brief summary reporting. In a general way the opinion has been confirmed that radiation acts on tissues roughly in proportion to the specific ionization whether the radiations come from outside the body or from a radioactive element inside the body. Fission products and plutonium have not been available long enough for really chronic experiments to be completed, and therefore such experiments remain as a postwar project for some interested group.

The objective of the Health Division of the Plutonium Project was, as stated by Smyth, "a negative one, namely to be sure that no one was seriously effected by the hazards peculiar to the enterprise. In this the group of workers has been successful." In fact, Smyth states, "factors of safety used in plant design and operation are so great that the hazards of the home and the family car are far greater for the personnel than any arising from the plants." However, while the workers appear to have been guided safely through radiation hazards, the objective of a better understanding of the action of radiations on living matter with all that such an understanding would imply in a practical and theoretical way has not yet been attained. Nucleonics, the science of the atomic nucleus, is only in its infancy. The more it is pursued, the more chance there is for accidents and the more the need therefore of a better understanding of the bio-medico-physical problems.

THE DEVELOPMENT OF THE FIRST CHAIN REACTING PILE

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(Read November 17, 1945, in the Symposium on Atomic Energy and its Implications)

It has been known for many years that vast amounts of energy are stored in the nuclei of many atomic species and that their release is not in contradiction with the principle of the conservation of energy nor with any other of the accepted basic laws of physics. In spite of this recognized fact, it was the general opinion among physicists until recently that a large scale release of the nuclear energy would not be possible without the discovery of some new phenomenon.

The reasons for this somewhat negative attitude were the following: Two types of processes in which nuclear energy could be released might be considered in principle. Various nuclear reactions take place spontaneously with production of energy when two nuclei are brought in contact. The simplest of many possible examples is perhaps that of ordinary hydrogen. Two hydrogen nuclei when brought in contact are spontaneously capable of reacting forming a deuterium nucleus and emitting an electron. The energy liberated in this process is about 1.4 Mev per process, equivalent to 1.6×10^{10} calories per gram or about two million times the combustion energy of an equal amount of coal. The reason why hydrogen is not a nuclear explosive is that two hydrogen nuclei never come in contact under ordinary conditions, owing to the repulsion of the positive electric charges of the two nuclei. There is no theoretical reason that prevents the coming together of the two nuclei; indeed this could be achieved both by very high temperatures and by very high pressures. Temperatures or pressures that are, however, well beyond the limits that could be achieved by ordinary means. Actually temperatures large enough to permit nuclear reactions to proceed at an appreciable rate are prevalent in the interior of many stars, in particular of the sun; these reactions are generally recognized as the main source of the energy irradiated by the stars.

A second possible pattern for the liberation of nuclear energy is the chain reaction. In most nuclear disintegrations particles are emitted (α-particles, protons, or neutrons) which in their turn are capable of producing new reactions. One can then conceive the possibility that when a first reaction takes place the particles produced by it may have a sufficient activity to determine in the average more than one similar reaction. When this is the case in each "generation" the number of reacting nuclei increases until the process "burns" a sizable fraction of the original material. Whether the chain reaction develops or not depends on whether the number of new processes produced by the particles emitted by a first process is larger or smaller than one. This number is called "reproduction factor."

For all processes known until the discovery of fission early in 1939, however, the reproduction factor was in all cases enormously smaller than one. The fission process opened a new way. Almost immediately after the announcement of the discovery the possibility was discussed that when the two fragments separate they may be excited so highly that neutrons may "evaporate" out of them. This conjecture was soon confirmed by experimental observations on both sides of the Atlantic.

In the spring of 1939 it was generally known that a fission that can be produced by the collision of a single neutron with a uranium atom was capable of producing more than one new neutron, probably something of the order of two or three. It was felt at that time by many physicists that a chain reaction based on the uranium fission was a possibility well worth investigating.

At the same time this possibility was viewed with hope and with great concern. Everybody was conscious early in 1939 of the imminence of a war of annihilation. There was well founded fear that the tremendous military potentialities that were latent in the new scientific developments might be reduced to practice first by the Nazis. Nobody at that time had any basis for predicting the size of the effort that would be needed, and it well may be that civilization owes its survival to the fact that the development of atomic bombs requires an industrial effort of which no belligerent except the United States would have been

capable in time of war. The political situation of the moment had a strange effect on the behavior of scientists. Contrary to their traditions, they set up a voluntary censorship and treated the matter as confidential long before its importance was recognized by the government and secrecy became mandatory.

To proceed with the steps that led to the development of the chain reaction, I would like to point out that, on the basis of the information available at the end of 1939, two lines of attack to the problem appeared worth while. One involved as a first step the separation out of ordinary uranium of the rare isotope 235 which is responsible for the slow neutron fission of uranium. Since this separation eliminates the parasitic absorption of neutrons by the abundant isotope 238, it was felt that once uranium containing a high percentage of 235 were available it would be easy to produce a chain reaction. The real difficulty was of course to obtain isotope separation on a large scale.

The second line of attack, the one that I propose to discuss in this paper, envisaged the use of natural uranium. The problem to assemble this material in a way proper to produce a chain reaction is of course considerably more tricky than the similar problem for U-235. Indeed the neutrons produced by a primary fission must be used very sparingly in order to keep a positive surplus in spite of the loss due to the large parasitic absorption of U-238. Great care must be exerted in order to make the balance between useful and parasitic absorption of the neutrons as favorable as possible. Since the ratio of the two absorptions depends on the energy of the neutrons and, aside from details, is greater for neutrons of low energies, one of the steps consists in slowing down the neutrons from their initial high energy, which is of the order of 1 Mev, to an energy as low as that of thermal agitation. A simple process to achieve this end has been known for some time. It is based on the obvious fact that when a fast neutron collides against an atom and bounces off some of its energy is lost as recoil energy of the atom. The effect is greater for light atoms which recoil more easily and is maximum for hydrogen but quite appreciable also for all light elements.

In order to slow down the neutrons we shall have, therefore, to spread the uranium throughout a mass of some convenient light element. The most obvious choice would be the lightest element, hydrogen, which has currently been used in its combination forms of water or paraffin for the slowing down of neutrons. Further study indicates, however, that hydrogen is not well suited to the purpose. This is due to the fact that the hydrogen nuclei have an appreciable tendency to absorb neutrons with which they combine to form the heavy hydrogen nucleus, deuterium. For this reason when hydrogen is used for slowing down the neutrons a new parasitic absorption is introduced which eats up dangerously into the small positive excess of neutrons needed to maintain the chain reaction.

Other light elements had, therefore, to be considered for slowing down the neutrons. None of them is as effective as hydrogen for this purpose but it was hoped that their lower absorption might overcompensate for this drawback. Very little was known in 1939 of the absorption properties of many light elements. Only in a few cases rather uncertain upper limits were to be found in the literature. The most obvious choices appeared at the time to be deuterium in the form of heavy water, helium, beryllium, or carbon in the form of graphite.

In the discussions that we had in the group working on the problem at Columbia University in 1939 and 1940, and which included George Pegram, Leo Szilard, and Herbert Anderson, we reached the conclusion that graphite offered the most hopeful possibilities due primarily to the ready availability of this substance. In the spring of 1940 experimental work on the properties of graphite was initiated at Columbia University using a few tons of graphite supplied to us through the Chairman of the Uranium Committee, Dr. Briggs. Two problems were attacked and solved at that time. One consisted in the determination of the absorption properties of graphite for neutrons and one in the study of its effectiveness for slowing down neutrons. The technique used in these experiments consisted in setting up a square column of graphite a few feet thick. A small source of neutrons consisting of a few grams of beryllium mixed with radon, or radium, was placed on the axis of this column. The neutrons emitted by it diffuse through the column and are gradually slowed down to thermal agitation energy; they keep on diffusing after this until they are either absorbed or diffuse out of the column. The distribution, both in space and energy, of the neutrons throughout the column was mapped using detectors sensitive to neutrons of various energies and the results were fitted into

a mathematical theory of the diffusion process. The results of these investigations permitted to develop a mathematical method for calculating with fair accuracy all the life history of a neutron from the moment of its emission as a fast neutron to the moment of its final absorption.

At the same time work was initiated in order to determine the excess number of neutrons emitted by natural uranium when a thermal neutron is absorbed by it. Since a considerable fraction of the thermal neutrons absorbed by uranium is captured by U-238 and does not give rise to fission, this excess turns out to be fairly small and makes it therefore very essential to avoid as much as possible parasitic losses so as to end up with a positive margin that may make the chain reaction a possibility. A simple trick permits a very considerable reduction of the parasitic losses that take place while the neutron is being slowed down. Instead of spreading the uranium uniformly throughout the mass of graphite, it is more convenient to arrange it in lumps distributed in some suitable lattice configuration throughout the graphite. This device makes it less probable for a neutron to encounter a uranium atom during the slowing down process when its energy makes it particularly vulnerable to parasitic absorption.

In working out the effectiveness of this method, the group working at Columbia was very materially reinforced by the collaboration with a new research group that was set up at Princeton University. In the spring of 1941 sufficient data on the details of the process had been gathered to enable one to form a relatively clear picture of the importance of the various factors and of the best devices to be used in order to minimize the unfavorable items.

In principle it would be possible to measure with great accuracy the absorption and scattering properties of neutrons for all energies and for all atoms involved and to use these results in a mathematical theory of the process so elaborate as to make it possible to predict the behavior of a given system accurately enough to answer the question whether a given system would or would not be chain reacting purely on a basis of calculation. The practical feasibility of this program did not appear too hopeful. We know now that the positive excess that makes possible a chain reaction in a graphite-uranium system is of only a few per cent. Since many factors of absorption and production of neutrons enter in the final result, it is clear that they should be known individually with extreme accuracy to make a prediction possible. The measuring methods developed up to 1941 seldom permitted the measurement of nuclear properties with an accuracy better than 10 per cent and were therefore inadequate to give a basis for calculations that would permit answering in a reliable way the question of whether the chain reaction with natural uranium and graphite was or was not possible.

In any system of finite dimensions some neutrons escape by diffusing out of its surface. This loss of neutrons by escape can in principle be eliminated by increasing the size of the system. It was clear in 1941 that the balance of neutrons capable of sustaining a chain reaction, even if at all positive, would be so small as to make it necessary to use a system of very large size in order to eliminate most of the loss of neutrons by escape. It was important to devise methods capable of answering the following questions: (1) whether a system containing lumps of uranium distributed through the graphite in a given lattice arrangement would become chain reacting provided its dimensions were infinitely large; and (2) assuming a positive answer to the previous question, what minimum dimensions would be needed actually to achieve the chain reaction? These minimum dimensions are usually called the critical size of the pile. Since the method of detailed calculation from the values measured for the constants was inadequate as explained before, one had to devise some way that would give more directly the required answers.

A brute-force method for this would be to set up a system of the given structure and keep on adding to it until a chain reaction actually is achieved or the system refused to react even when built up to enormous size. This method obviously would be exceedingly expensive both in materials and labor. Fortunately it is possible to obtain a fairly accurate answer to the two questions by using a relatively small sample of the structure under investigation. The first experiments of this type, the so-called intermediate or exponential experiments, were set up at Columbia University in the summer and fall of 1941. A lattice structure was set up containing cans filled with uranium-oxide spread throughout a mass of some thirty tons of graphite. A primary source of neutrons was inserted at the bottom of this mass and the distribution of the neutrons throughout the mass was in-

vestigated in detail and compared with the theoretical expectation.

The result of this first experiment was somewhat discouraging in that it indicated that a system of that structure, even if built up to infinite size, would still have a negative balance of neutrons and more precisely a loss of 13 per cent of the neutrons each generation. In spite of this negative result hope was not abandoned. Indeed sizable improvements to this first structure could be expected as indicated below.

Early in 1942 all the groups working on the production of a chain reaction were united at the Metallurgical Laboratory of the University of Chicago under the general leadership of Arthur Compton. During 1942 some twenty or thirty exponential experiments were carried out at Chicago in the attempt to improve on the conditions of the first experiment. Two different types of improvements were pursued. One consisted in a better adjustment of the dimensions of the lattice and the other in the use of better materials. Impurities had to be eliminated to a surprisingly high extent from both uranium and graphite since the parasitic absorption due to elements appearing as common impurities in uranium and graphite was responsible for a loss of an appreciable fraction of the neutrons. The problem was tackled to organize large-scale production of many tons of graphite and uranium of an unprecedented purity. Also the production of uranium in metallic form was vigorously pursued. Up to 1941 uranium metal had been produced only in very small amounts, often of questionable purity. Uranium metal was mostly produced in the form of a highly pyrophoric powder which in several cases burst spontaneously into flames when coming in contact with air. These pyrophoric properties were only somewhat reduced by sintering the powder into compact blocks. Some of these sintered blocks were used in exponential experiments carried out in order to obtain information on the properties of a system containing metallic uranium; while the experiments were in progress the blocks were burning so fast that they felt hot to the touch and we were afraid that they might actually burst into flames before we could go through with the experiment.

Toward the fall of 1942 the situation as to the production of materials gradually improved. Through the joint efforts of the staff of the Metallurgical Laboratory and of several industrial firms, better and better graphite was obtained. Industrial production of practically pure uranium-oxide was organized and some amount of cast uranium metal was produced. The results of the exponential experiments improved correspondingly to the point that the indications were that a chain reacting unit could be built using these better brands of materials.

The actual erection of the first chain reacting unit was initiated in October 1942. It was planned to build a lattice structure in the form of a huge sphere supported by a wooden structure. The structure was to be erected in a Squash Court on the campus of the University of Chicago. Since we were somewhat doubtful whether the dimensions as planned would be sufficiently large, the structure was actually built inside a huge tent of balloon cloth fabric that in case of need could have been sealed for the purpose of removing the air in order to avoid the parasitic absorption of the atmospheric nitrogen. This precaution actually proved unnecessary.

It took a little over one month to build the structure. A large number of physicists, among them W. H. Zinn, H. L. Anderson, and W. C. Wilson, collaborated in the construction. During this time the approach to the chain reacting conditions was followed day by day by measuring the neutron intensity building up inside the pile. Some neutrons are produced spontaneously by uranium in very small numbers. When the system approaches the critical size, each of these neutrons multiplies for several generations before final absorption. Indeed, when the reproduction factor of the pile is, for instance, 99 per cent, each neutron multiplies in the average one hundred generations. Consequently, the density of neutrons increases throughout the mass as the critical dimensions are approached and tends to diverge at the critical size. By watching the rise of the neutron density, one obtains, therefore, a positive method for extrapolating to the critical size.

Appreciably before the dimensions originally planned for the structure were reached, the measurements of the neutron density inside the structure indicated that the critical size would soon be attained. From this time on work was continued under careful supervision so as to make sure that criticality would not be inadvertently reached without proper precautions. Long cadmium strips were inserted in slots that had been left for this purpose in the structure. Cadmium is one of the most powerful absorbers of neutrons and the absorption of these strips was large enough to make sure that no chain reaction could take place while

they were inside the pile. Each morning the cadmium strips were slowly removed, one by one, and a determination of the neutron intensity was carried out in order to estimate how far we were from the critical conditions.

On the morning of December 2, 1942, the indications were that the critical dimensions had been slightly exceeded and that the system did not chain react only because of the absorption of the cadmium strips. During the morning all the cadmium strips but one were carefully removed; then this last strip was gradually extracted, close watch being kept on the intensity. From the measurements it was expected that the system would become critical by removing a length of about eight feet of this last strip. Actually when about seven feet were removed the intensity rose to a very high value but still stabilized after a few minutes at a finite level. It was with some trepidation that the order was given to remove one more foot and a half of the strip. This operation would bring us over the top. When the foot and a half was pulled out, the intensity started rising slowly, but at an increasing rate, and kept on increasing until it was evident that it would actually diverge. Then the cadmium strips were again inserted into the structure and the intensity rapidly dropped to an insignificant level.

This prototype of a chain reacting unit proved to be exceedingly easy to control. Intensity of its operation could be adjusted with extreme accuracy to any desired level. All the operator has to do is to watch an instrument that indicates the intensity of the reaction and move the cadmium strips in if the intensity shows a tendency to rise, and out if the intensity shows a tendency to drop. To operate a pile is just as easy as to keep a car running on a straight road by adjusting the steering wheel when the car tends to shift right or left. After a few hours of practice an operator can keep easily the intensity of the reaction constant to a very small fraction of 1 per cent.

The first pile had no device built in to remove the heat produced by the reaction and it was not provided with any shield to absorb the radiations produced by the fission process. For these reasons it could be operated only at a nominal power which never exceeded two hundred watts. It proved, however, two points: that the chain reaction with graphite and natural uranium was possible, and that it was very easily controllable.

A huge scientific and engineering development was still needed to reduce to industrial practice the new art. Through the collaboration of all the men of the Metallurgical project and of the Du Pont Company, only about two years after the experimental operation of the first pile large plants based essentially on the same principle were put in operation by the Du Pont Company at Hanford, producing huge amounts of energy and relatively large amounts of the new element, plutonium.

RESONANCE REACTIONS

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(Read November 17, 1945, in the Symposium on Atomic Energy and its Implications)

I AM going to tell you about a small phase of the work on atomic energy. The subject of "Resonance Reactions" was chosen not only because I was personally very much interested in it but also because the Army very obligingly cleared some of the underlying information for publication. In addition to the technical information which I would like to tell you about, I hope to demonstrate that in many cases very abstract mathematical considerations perform a very real and very necessary function for simple practical purposes. The purpose in this case was the establishment of a nuclear chain reaction with a view of producing plutonium.

I will be speaking about the chain reacting piles many of which now are, or were at one time, in operation. They contain graphite to slow down the neutrons and uranium as active substance. The neutrons in such a pile have one of four possible fates. They may escape from the pile—and this constitutes a total loss. They may be absorbed in the graphite or in impurities—and this also constitutes a total loss. The rest of the neutrons are absorbed in the uranium—either in the heavier isotope, i. e. U–238, or in the lighter one, i. e., U–235. The effects of the last two kinds of absorption are very different, one could even say opposite to each other. The neutrons absorbed in the heavier isotope essentially transform this isotope into plutonium. They perform, therefore, a most useful function. Those which are absorbed in the lighter isotope, on the other hand, destroy this isotope which is a most valuable nucleus. However, the act of destruction liberates neutrons and some of these can then be used again for the production of plutonium. The diagram which you see (fig. 1) illustrates the situation. The various arrows are the neutrons and they all originate from the process accompanying the absorption of a neutron by the U–235. This absorption process does not give any useful product except the neutron. The neutron itself is useful in the pile only because it can be absorbed, and is absorbed in a relatively large fraction of the cases by the U–238 thus giving plutonium. However, in spite of the fact that absorption by the U–235 does not give a useful final product, one must see to it that sufficiently many neutrons remain for this type of absorption to produce as many neutrons as were absorbed by all four absorption processes together. If this is not the case, the number of neutrons in the pile will decrease and the pile will finally stop operation. One can even say that furnishing enough neutrons to the U–235 is the prime concern when designing a pile. The whole first year of the Chicago Project was spent, one could say, in the endeavor to ascertain the conditions under which the U–235 receives enough neutrons. Dr. Fermi has just told you about the successful conclusion of these endeavors.

In order to supply the U–235 with enough

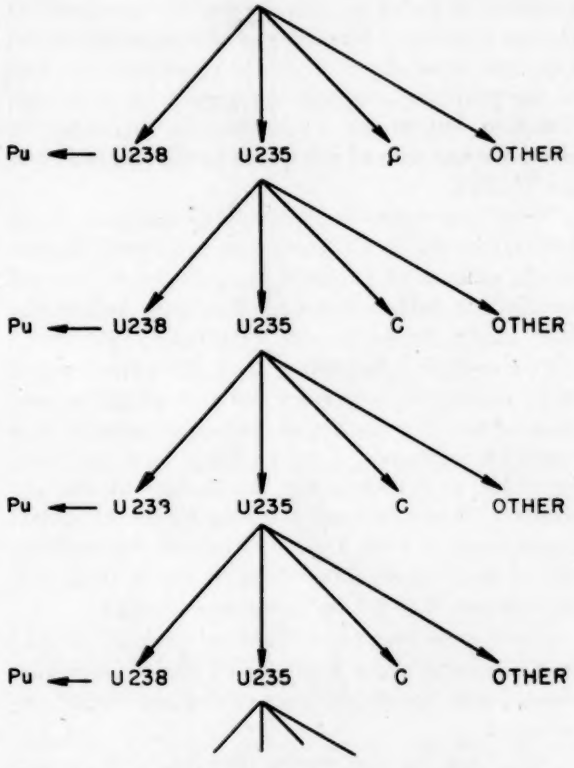

FIG. 1. Schematic representation of the chain reaction.

neutrons one will try, first of all, to make the losses—that is the arrow to the extreme right—as small as possible. One will also try to make the absorption in the graphite as small as possible and one is very much tempted, at this point, to reduce the amount of the graphite in the pile to the vanishing point. One even tries to reduce the percentage absorption by the U–238 to as little as possible although it is this absorption which gives the desired product. One realizes the necessity of economizing with the neutrons as much as possible in order to keep the reaction alive.

It is this last point about which I want to speak. The U–238 absorbs a certain number of thermal, that is low energy, neutrons, and nothing can be done about this as long as one uses natural, unenriched uranium. In addition, the U–238 also absorbs some neutrons before these lose all their energy of motion to the graphite. It is the absorption of these neutrons that can be reduced. Through it, the U–238 takes a toll on the neutrons before the U–235 has any chance because the U–235 absorbs the neutrons only after they have been slowed down nearly completely. At this point one is tempted to overload the pile with graphite in order to slow down the neutrons as fast as possible. However, if one remembers the third arrow of figure 1, which represents the loss to the graphite, one will not go too far into that direction but strike a compromise in order to minimize the sum of the losses to the graphite and the U–238.

What one wants is evidently an analysis of the neutron losses in all processes, how they depend on the amount of graphite, etc. Perhaps I should mention in this connection that long before the first chain reaction was established we could gather enough information from the experimental work to be able to predict the multiplication constant of any U-C lattice almost as accurately as it could be measured, i. e., to about one per cent. In order to calculate the losses due to the absorption of non-thermal neutrons by the U–238, it is necessary to form a clear picture of the mechanism of this absorption. It is in connection with this picture that I have some new results.

Early experiments of Szilard [1] and of Fermi [2] on the absorption of neutrons by various elements showed that the dependence of the absorption coefficient on neutron energy is far from simple. There are no data in the literature which I could conveniently show to illustrate this point. Instead of this, I will show the absorption coefficient of protons by fluorine which was measured in 1937 and 1938 by Herb, Kerst, and McKibben [3] at the University of Wisconsin.

The appearance of this curve (fig. 2) closely resembles that of an optical spectrum and in fact the theory of these processes, developed by G. Breit [4] and myself but shortly before Herb's experiments, closely resembles the theory of optical absorption. One can visualize the process of neutron absorption as the succession of two processes: the first is the absorption of the neutron to form an excited state of the product nucleus. This excited nucleus still can reemit the neutron just as an excited atom can reemit the absorbed light quantum. On the other hand, the excited nucleus can stabilize itself also by emitting other kinds of radiation, in our case by emitting γ-quanta. This last alternative leads to a stable nucleus and a real and final absorption of the neutron.

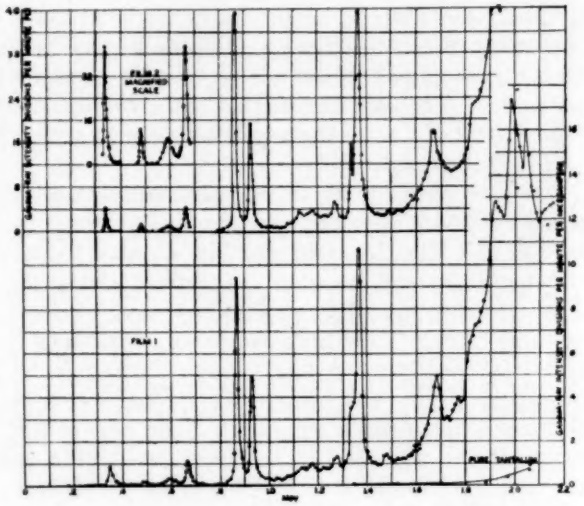

FIG. 2. Yield of γ-rays from fluorine as function of energy of incident protons.

The work of Breit and myself was carried out with the mathematical tools which are familiar

[1] Moon and Tillman, *Nature* **135**: 904, 1935; Szilard, L., *Nature* **136**: 150, 1935.

[2] Amaldi and Fermi, *Ric. Scient.* **1**: 310, 1936.

[3] Hafstad, Heydenburg, and Tuve, *Phys. Rev.* **50**: 504, 1936; Herb, Kerst, and McKibben, *Phys. Rev.* **51**: 691, 1937; Bernet, Herb, Parkinson, *Phys. Rev.* **54**: 398, 1938.

[4] Breit and Wigner, *Phys. Rev.* **49**: 519, 1936.

from the calculation of optical phenomena. However, the basic equations which apply for neutron absorption are not the same as those for light absorption, and the calculation which Breit and I carried out represents a less good approximation than are the well known calculations on light absorption. Furthermore, they did not bring out very clearly what physical assumptions one has to make in order to obtain a resonance formula and an energy dependence for the cross section of the reaction similar to that of an optical spectrum. Numerous attempts have been made to remedy these difficulties, partly by Breit himself.[5] The most notable of these attempts is due to A. Siegert.[6] It is along the lines of his paper that I proceeded. Briefly, the assumption which proved fruitful was that in a resonance reaction the wave function of the compound nucleus, that is the nucleus which is formed through the original capture of the neutron, is, within the resonance region, independent of energy. Of course, the probability for having the system in this compound state does depend on energy and turns out to be greatest at exact resonance, but the state itself is qualitatively independent of energy. From this the rule follows easily that the disintegration probability of the compound nucleus into a particular pair of fragments is proportional to the relative velocity of those fragments. The same holds, of course, also for the probability of the formation of the compound nucleus from a pair of colliding particles. This rule is most important for the process of absorption of slow neutrons in which we are interested; it shows, e. g., that once the compound nucleus has been formed the reemission of the neutron has only small probability as long as the total energy of the system is so low that it does not suffice to give an appreciable velocity to the neutron to be emitted.

The total probability of a reaction then contains three factors. The first one is the above specific probability, characteristic for a definite pair of colliding particles, for the formation of the compound nucleus. The second factor is the familiar resonance factor which has the same form as for light absorption. The third factor is the probability for a definite type of disintegration of the compound nucleus to complete the reaction. The formula is the same as originally derived in collaboration with Breit but the derivation is different.

There are, however, a few points where the new method goes further than the older one and I would like to mention these briefly. The first point is the calculation of the anomalous scattering of neutrons. Here a formula, proposed already by Bethe,[7] could be corroborated except that the reality conditions are such as Oppenheimer [8] has suspected them to be. Naturally, in the neighborhood of the resonance lines, neutron absorption is much more probable than neutron scattering. Just the same, even the scattering coefficient assumes much higher values than far from a resonance. If one knows the characteristics of a resonance as far as neutron absorption is concerned, the neutron scattering can be calculated except for the sign in the equations. This ambiguity in sign corresponds to the two curves of figure 3. The abscissa is the neutron energy.

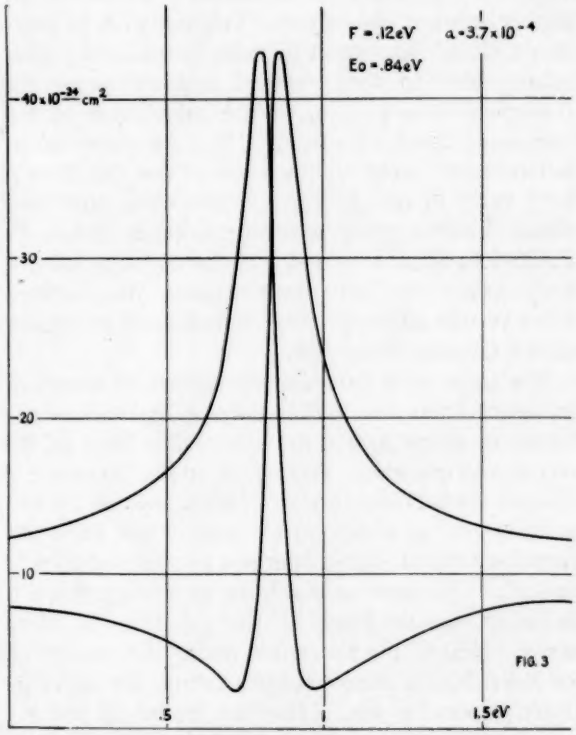

FIG. 3. Cross section of anomalous scattering as function of energy.

[5] Breit, G., *Phys. Rev.* **58**: 506, 1068, 1940. These articles contain further references to the literature.

[6] Siegert, A. J. F., *Phys. Rev.* **56**: 750, 1939.

[7] Bethe and Placzek, *Phys. Rev.* **51**: 450, 1937; Bethe, H. A., *Rev. Mod. Phys.* **9**: 71, 1937.

[8] Kalckar, Oppenheimer, and Serber, *Phys. Rev.* **52**: 273, 279, 1937.

the ordinate the scattering power. The maximum absorption occurs for the energy at which the two curves intersect. No matter which curve holds in a particular case, the scattering power is anomalously low at one side of the maximum absorption, anomalously large at the other side. In the case of this figure, which is based on the absorption data of Rh, the scattering becomes at maximum more than four times greater than its average value.

The second point where some progress could be made is the calculation of the effective lifetime of the compound nucleus and, what is closely related to this, the index of refraction for neutrons. This latter quantity has already been calculated outside the resonance by Fermi and also by Seitz but the conditions near the resonance show some interesting features which are not present far from the strongly absorbing region. The refractive index is of importance for interference phenomena of neutron waves.

The third point concerns the behavior of resonances of higher angular momenta and a fourth the region between resonances. I do not wish to enter into a closer discussion of these points and rather return now to the practical application of the resonance theory, i. e. to the calculation of the resonance absorption by U–238. All these calculations were made on the basis of the old theory, very early in one project. They were published about simultaneously with our work in Russia by Zeldovich, Khariton, and Kurchatov,[9] and others. I do not doubt that the Germans also derived these results although they do not seem to appear in the German literature.

We have seen that the absorption of neutrons is, apart from the lowest energy region concentrated in sharp bands, the absorption lines of the element in question. According to the literature,[10] U–238 should have an absorption line at 10 eV, another one at about 30 eV and it will have absorption lines at higher energies also, about equally spaced. The neutron also loses its energy, while it is being slowed down by the graphite, in finite steps. Hence, the spectrum which the energy of an individual neutron assumes during the slowing-down process is also a line spectrum. If the absorption spectrum of the U–238 has a line in common with the energy spectrum of the neutron during its slowing-down process, the neutron will be absorbed with a high probability.

Of course, the set of energy values which one neutron goes through while it is slowed down is different from the set of energy values which another neutron goes through. The whole problem is a statistical one; it is the question of the probability for the coincidence of a line in a fixed spectrum—that is the neutron absorption spectrum of U–238—with a line in another, variable spectrum, which consists of the energy values of the neutron. Roughly speaking, this probability of coincidence, which is at the same time the probability of the absorption by the U–238, is proportional to the number of levels in the second spectrum or inversely proportional to the average energy loss per collision. It is apparent, from this point of view, that the addition of a pure scatterer will increase the resonance absorption because collision with it will give the neutron a new energy value which is only slightly below the previous energy value so that the number of lines in the neutron energy spectrum will increase and with it will increase the probability of a coincidence with a line in the absorption spectrum of U–238.

The mathematical expression which one obtains from the above picture gives for the resonance absorption of a line approximately

$$\frac{\pi w \sigma_{\max}}{2SE}\sqrt{\frac{\sigma_s}{\sigma_{\max}+\sigma_s}}$$

In this S is the slowing-down power of the medium, w is the width of the absorption line, $\sigma_{\max}$ is the depth of absorption at resonance and σ_s the scattering cross section.

There is another reason, in addition to those previously mentioned, why I have chosen the resonance absorption as the subject of my address. I chose it because it is particularly easy to show that the results which were obtained on the subject by the Chicago Project were obtained also in other countries. The same holds for most problems which we tackled, probably to an even greater extent than we realize. Why is it then that ours is the only country where the U work was seriously undertaken and successfully concluded? Part of the reason is undoubtedly that we were practically free from enemy interference. But I do not believe that this was the only reason.

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[9] Zeldovich and Khariton, *Jour. Exp. Theor. Phys.* **10**: 129, 1940. Review article by I. V. Kurchatov, *Bull. Acad. Sci. U. S. S. R.* **5**: 555, 1941.

[10] Anderson, H. L., *Phys. Rev.* **57**: 566, 1940; Meitner, Hahn, and Strassman, *Ztsch. Phys.* **106**: 249, 1937.

Our physicists and chemists felt that we were citizens of this country, not subjects of it. We felt implicitly responsible for its safety and well being, we were accustomed to urging our opinions on others, even on others in authority, if we thought we could judge a question better than they could. If we felt that we did not have the ears of the authorities in charge, we felt free to go to the highest authority of the country. It may have been necessary to curtail our freedom in these respects as long as we were in the fight. But now, when the fight is over, we hope not only in the interest of science but also in that of the whole country that our freedom will be fully restored.

METHODS AND OBJECTIVES IN THE SEPARATION OF ISOTOPES

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(Read November 17, 1945, in the Symposium on Atomic Energy and its Implications)

In choosing a subject for this symposium there have been a number of limitations imposed by various circumstances. The subject needed to be one bearing on the general subject of this symposium and also one for which I might claim some competence. The interesting process for the separation of isotopes at the present time is that involved in the separation of uranium-235 and uranium-238. However, this subject is largely classified. There are certain phases of this work that might be declassified in the eyes of the military authorities, but, since there is a declassification committee, of which I am a member, working on the declassification of work of this kind, I felt that it was an inopportune time to ask for any easing of present restrictions. Also, a presidential order forbids comparison of technical methods of separation used and not used, and costs and production of existing plants. I have, therefore, decided to discuss the general methods of isotope separation and refer to the separation of the uranium isotopes only to the extent that this subject is revealed in the report by H. D. Smyth.

The isotopes of the elements were originally supposed to be identical in chemical properties, and thus no chemical methods would be applicable for their separation. Today we know that this is not rigorously true, but the similarity in chemical properties of the isotopes of all elements with the exception of hydrogen is far greater than the similarity in chemical properties between the most like elements, namely the rare earths, and hence the separation by such methods which have been developed in the past for such purposes is largely not practical.

There are two types of methods which have been used for the separation of isotopes. The first of these, in theory at least, makes possible a complete separation in one operation. These methods depend upon the action of electrical and magnetical fields on ions of the elements in question. The second group of methods depends upon small changes in the relative abundances which can be made in a single operation. These methods require the application of repeated operations to secure any over-all large change in the ratio of isotopes. We shall refer to these latter methods as statistical methods.

If ions of an element are produced in an arc, it is possible to draw them out of the region of the arc with an electric field. Since the energy given to the ion is the same regardless of its mass, the velocity acquired by the ion while falling through an electric field is inversely proportional to the square root of its mass. Thus, the light isotopes move faster than the heavy ones in the ratio of the square roots of their masses. If the beam of ions of this kind is allowed to travel through an evacuated space for some distance, the light ions will move ahead of the heavy ions and, if a bunch of ions is admitted to this space, the light atoms should become completely separated from the heavy ones at a suitable distance. If an alternating electric field is applied to these ions and properly timed, the light ones may be deflected from the original direction in one direction and the heavy ones deflected in another. The separation should be effected by sending a bunch of ions down an evacuated space and deflecting them at an appropriate time and thus separating them into two fractions. Modifications of this method can be made; theoretically a complete separation is possible. In practice it will be found that problems of space charge which makes the bunches diffuse and the problem of admitting a sharp bunch of ions will limit the separation secured. The difficulties in the method reside mostly in securing a large enough number of ions to make the separation of isotopes possible on the large scale. This method was tried first approximately twenty years ago and was tried again for the uranium isotopes, but was not carried sufficiently far to secure large productions.

The existence of isotopes of the elements was first demonstrated by the use of mass spectrographs which can be constructed in a variety of ways. Such instruments can be adapted to the separation of isotopes. In this case, ions are accelerated from an arc and passed through slits into an evacuated space between the poles of an electro-

magnet. The ions move in circles in a magnetic field, the heavier ones moving on a circle of larger diameter than the light ones, and thus separation of the ions occurs. The isotopes of different atomic weight arrive at different points in the apparatus after describing approximate semi-circles and can be collected by suitable ion collectors. Again the limitations of this method reside in the problems of space charge, securing a sufficient beam of ions, and many problems of introducing the element into the apparatus and the removal of the product therefrom. This method of separation, as I have said, was used in demonstrating the existence of isotopes and for determining their exact atomic weights. It has been used for the separation of uranium isotopes on a large scale. The development of this process was carried out at the University of California under the direction of E. O. Lawrence.

The statistical methods for the separation of isotopes can be divided further into two types. First there are those which require a cascade of simple units. In such a cascade the simple unit produces a small change in the relative abundance of the isotopes. The light fraction is sent to a succeeding unit and the heavy fraction to a preceding unit of the cascade. The number of units required for a given production and a given over-all change in the abundance of isotopes depends upon the fractionation that is secured in a single unit and the capacity of that unit. In the second group of methods counter-current flow can be utilized, and in this case the number of separate units in the cascade can be very substantially decreased. The first type of process depends upon kinetic phenomena, that is, the rapidity with which processes take place; and the second type depends upon equilibrium processes or pseudo-equilibrium processes.

To the first type of statistical processes belong diffusion through solid membranes, evaporation from liquids, and the electrolysis of electrolytic solutions containing the element which it is desired to separate. A cascade of such units is constructed according to the diagram of figure 1.

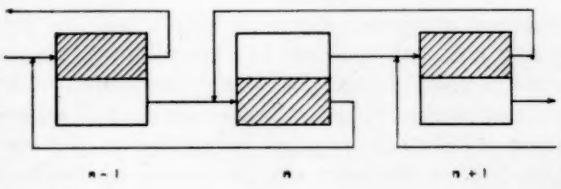

FIG. 1.

This figure shows the flows as they are required for the $(n-1)$th, nth, and $(n+1)$th units. The entire cascade consists of many units of this kind, thousands in the case of the diffusion separation of the uranium isotopes, less in the case of other isotopes, such as those of nitrogen and carbon.

The diffused or light fraction moves to the right and the undiffused or heavy fraction to the left. The division represents the diffusing membrane. Other kinetic statistical methods operate in a similar way.

The rate of diffusion through a porous membrane at sufficiently low pressures, providing the membrane has sufficiently small holes, will be proportional to the square root of the ratio of the molecular weights. In the case of uranium the diffusion was carried out with uranium hexafluoride and, since the molecular weights of the two varieties of uranium hexafluoride molecules are 349 and 352, the theoretical ratio becomes 1.0043. In the case of other isotopes the ratio is usually considerably more favorable. Using methane the two isotopes of carbon furnish molecules of molecular weights 16 and 17, and the square root of the ratio of these numbers is 1.031, thus giving a much more favorable ratio.

Difficulties are encountered which make the ideal ratio unattainable and in fact undesirable to use in practice. In order to secure the maximum separation very low pressures must be used, but this, of course, cuts down the rate at which diffusion through the porous membrane occurs. It is better to use higher pressures and thus a lower fractionation in the unit but at the same time a higher rate of flow through the membrane if one wishes to make the plant of a minimum size. There are also problems of back diffusion and mixing of the gases to be diffused on the high pressure side of the membrane. This method of separation has been used in the case of carbon, nitrogen, oxygen, neon, chlorine, argon, and bromine as well as uranium. The plant for the separation of uranium by this method was successful and is, in fact, the largest chemical plant for the production of one single product that I have ever seen. This cascade diffusion method was first devised by Hertz, and Dunning first proposed it for the separation of the uranium isotopes.

The rate of evaporation from the surface of a liquid at sufficiently low pressures will be inversely proportional to the square root of the molecular weight, and hence in such evaporation a fractionation of the isotopes will be secured, the

lighter one concentrating in the evaporated material. The fractionation secured in the simple processes will again be proportional to the square root of the ratio of the molecular weights. In the higher pressures some fractionation will still be secured and a greatly increased rate of evaporation will be possible. This method was first demonstrated by Harkins, Mulliken, and Hevesey some twenty years ago. The method has not been used for the separation of isotopes on a large scale, but it does seem that the method is worthy of considerable more development than it has received so far. In particular it was not seriously considered for the separation of the uranium isotopes because a liquid of low vapor pressure is required for this process and no such liquid compound of uranium is known.

If water containing an electrolyte is electrolyzed, hydrogen and oxygen are produced at the cathode and anode respectively. It was early demonstrated by Washburn that the hydrogen so produced contained less heavy hydrogen than was contained in the water in the electric cell. Experiments made since that time indicate that the fractionation secured in this way is very great. Often times the fractionation factor is as high as 7 or 10 and has been reported to be as high as 20. This results in an effective fractionation of the hydrogen isotopes, and the first supplies of heavy hydrogen were secured in this way. The application of the method to other elements has been tried in the case of lithium, oxygen, and chlorine, but the fractionation factor in the case of lithium is only approximately 1.07 instead of approximately 10 in the case of hydrogen isotopes, and the fractionation factors for oxygen and chlorine are even less. In the case of the separation of the hydrogen isotopes cascade methods are not used because of the large effect secured in a single unit which makes possible the more convenient use of batch methods. In the case of the other elements mentioned the effects are so small that no effective separation of the isotopes of these elements has been carried out and, in fact, the method does not look feasible in the case of any other element besides hydrogen.

Farrington Daniels has suggested that difference in the velocity of chemical reactions might be used for separating isotopes. This appears to be a possible and perhaps effective method providing an appropriate chemical reaction can be secured. The method has not been used but, in case a desirable reaction can be found, the method would belong to these statistical group requiring a cascade of simple units.

The counter-current flow methods include distillation and chemical equilibria in exchange reactions, thermal diffusion, electrolytic mobility methods, and counter-current flow in centrifuges.

The distillation method was first used by Kiesam and van Djik in the case of the neon isotopes at approximately the boiling point of liquid neon where the ratio of the vapor pressures of neon-20 and neon-22 is about 1.04. The process consisted in distilling neon through a counter-current fractionation column of the type that is used in many chemical separations except that it was operated at about 40 degrees Kelvin. This method was also used for the first concentration of heavy hydrogen by distilling liquid hydrogen just above its triple point. Subsequently, it was learned that fractionation of the hydrogen isotopes and the oxygen isotopes was secured in the distillation of water and similar slight separations have now been observed in the case of many isotopic compounds of the lighter elements. In the case of hydrogen and neon approximate calculations could be made indicating that this difference in vapor pressure should be present by making use of the Debye Theory of the solid state and assuming that this theory should apply approximately to liquids. In the case of other substances no satisfactory theory for the observed effects has been secured. The phenomena giving rise to these differences in vapor pressures must be rather complicated and would probably involve a very considerable understanding of the liquid state. Thus Trouton's Rule, namely that the entropy of vaporization of a large class of liquids is the same at the boiling point, is not true for isotopic compounds. Trouton's Rule must depend upon fundamental properties of liquids, but isotopic liquids must owe their difference of vapor pressures to secondary effects.

Chemical exchange reactions can often be used for the separation of isotopes in ways that are quite similar to the distillation process. Thus ammonia gas can be brought to equilibrium with the ammonium ion dissolved as a salt in water. In this case the ratio of the nitrogen isotopes in the ammonia compound is greater than that in the ammonia gas with which it is in equilibrium in the ratio of about 1.026. It is only necessary to flow an ammonium nitrate solution down a fractionation column, add sodium hydroxide at the bottom, boil out the ammonia, and pass it up the fractionation column to secure a process analagous in

every way to distillation. By using this process the ratio to the nitrogen isotopes has been changed by a factor of 700. This process is used in the present time for the commercial production of concentrates of nitrogen-15. Analogous processes are used for the separation or effective concentration of the isotopes of hydrogen, carbon, and sulphur, and corresponding differences have been observed in the chemical properties of isotopic compounds in the case of lithium, oxygen, and potassium. These differences in chemical properties exist to an appreciable degree only in the lighter elements of atomic weight of 40 or less. The method was therefore not applicable to the uranium isotopes.

Clusius and Dickel demonstrated that the phenomena of thermal diffusion could be used for the separation of isotopes. The effect was predicted many years ago from studies on the kinetic theory of gases. The phenomenon depends upon the law of force between molecules in the gas state. If this law of force is the inverse fifth power of the distance, no separation can be secured. But in the case of most molecules the repulsive forces between molecules follows a higher inverse power of the distance, and hence separation can be secured. In this method a hot surface and a cold surface are mounted parallel to each other in a vertical direction. The light molecules concentrate preferentially on the hot surface, the heavy molecules at the cold surface. Convection is set up with the lighter fraction moving upward and the heavier fraction downward. If the ends of the apparatus are closed the process goes on until samples at the top and bottom are produced which differ markedly in isotopic composition. This method is a simple one and is especially useful when small amounts of isotopes are required. It has been applied to hydrogen, carbon, nitrogen, oxygen, neon, chlorine, xenon, and mercury. If a liquid is placed between the hot and cold surfaces, similar separations are observed though no satisfactory understanding of the phenomenon exists at the present time. Liquid thermal diffusion was applied to uranium hexafluoride by Abelson, and separation of the uranium isotopes was secured.

During the war many methods were tried for the separation of isotopes but only one new method was discovered. That was the electrolytic mobility method discovered by A. Keith Brewer. If an electric current is passed through a solution of potassium salt, the lighter potassium ion moves slightly more rapidly than the heavy one. This can therefore be used as a means of separating isotopes, though all experiments up to the present time produced only slight changes in the rates of the potassium isotopes, and no effects were observed in the case of solutions of uranium salts.

Early in the study of isotopes separation methods the centrifuge was proposed by Mulliken. In this case the heavier isotope preferentially concentrates at the outside of the centrifuge. The degree of separation depends upon the difference in atomic weight and not on the square root of the ratio of molecular weights and only slightly in other ways upon the atomic or molecular weight of the substance used. This means that this method is particularly useful if there are large differences in atomic weight and the effect does not markedly decrease with increasing atomic weight. In practice a long centrifuge can be used with a stream of gas flowing in one direction at the periphery of the centrifuge and in the opposite direction at the center. The two gas streams flow counter-current to each other just as it is possible to have winds blowing at different directions at different altitudes above the earth's surface. This establishes a counter-current flow in the centrifuge and makes possible a considerable separation in one unit. It is in fact analogous to the distillation process except that the elementary fractionation is produced by the centrifugal field and not by differences in vapor pressure. Some separation of isotopes has been secured by this method but no large change in concentration has been secured. This method was applied to uranium hexafluoride with considerable success though the decision finally was made to use the diffusion process instead of the centrifuge process for large scale work.

It is of interest to indicate briefly the methods which may be used advantageously to separate the lighter isotopes. The hydrogen isotopes, protium and deuterium, have been separated on a large scale by distillation of water and the exchange reaction between water and hydrogen gas. The rare helium isotope, He^3, can be concentrated by thermal diffusion or the distillation of liquid helium. (These have not been tried but it seems most likely that both will be effective.) The lithium isotopes have been partially separated by two exchange reactions, the Li^+-lithium zeolite and the Li^+-lithium amalgam methods. It should be possible to extend such methods to large scale separations. Beryllium is a pure element and hence the problem of separation of stable isotopes

does not arise. Boron is a mixture of two isotopes, and from the general properties of its compounds one may expect that chemical exchange reactions would be effective.

The carbon isotopes have been partially separated by thermal diffusion and by two chemical exchange reactions. The latter methods are considerably cheaper if large amounts are needed. The nitrogen isotopes have been separated by the exchange reaction between ammonium ion and ammonia gas and are now available commercially. The oxygen isotopes have been concentrated by the distillation of water and exchange reaction methods seem feasible. However, this separation requires extensive study in order to secure sufficient material for tracer studies. Fluorine, sodium, aluminum, and phosphorus are pure elements. Neon has been separated by thermal diffusion and fractional distillation and these are best for this element. Magnesium and silicon have not been separated by any methods. Sulfur has been separated by chemical exchange between sulfur dioxide and bisulfite ion, and chlorine by thermal diffusion using hydrogen chloride gas. Krypton and xenon have been fractionated by thermal diffusion. Presumably argon could be separated by the same method. Potassium has been fractionated by the potassium ion-potassium zeolite exchange but we do not know whether this method could be used to prepare approximately pure samples.

It may be that electromagnetic methods would be valuable for the preparation of small samples of isotopes of metallic elements throughout the periodic table.

This brief summary shows that this problem of separation of isotopes has progressed markedly in the years since their discovery but that much work remains to be done.

With this brief review of the methods of isotopic separation we turn to the question of the objectives for such work. In recent years there has been much justifying of science on the basis of its usefulness for peacetime or wartime pursuits. I do not believe that this is the primary objective of science. It serves ends of its own, namely a fundamental understanding of natural phenomena, and I wish to maintain that it is unnecessary that any of the things which we do in science shall have a utilitarian objective. Nevertheless, the fundamental phenomena underlying the separation of isotopes are not at all those in the forefront of science at the present time. We are interested in the forces between molecules and differences in chemical properties, and the fundamentals of diffusion phenomena. But these studies could hardly justify the effort that it is necessary to use for the separation of these varieties of the elements which are so very similar in their properties. Hence, it is necessary to justify such effort largely because of the ways that separated isotopes may be used in pure science or elsewhere.

It is now unnecessary to discuss the reasons for the separation of the uranium or the hydrogen isotopes because of their great usefulness in the development of atomic energy. Heavy hydrogen has had an important use for many years as a tracer for the investigation of chemical phenomena, and it should continue to have usefulness in this direction.

During recent years many radioactive isotopes have been produced in connection with the use of cyclotrons and also now in connection with the development of atomic energy. These substances will be very useful in the future for investigating many problems of chemistry, both in pure scientific researches and industrial applications. I think it safe to say that the next twenty-five years will enable us to unravel the many complicated and abstruse facts of intermediary metabolism. I might mention that there are two elements which do not have satisfactory radioactive isotopes for use in tracer techniques. These are nitrogen and oxygen. In addition, the sulphur isotope is not entirely satisfactory for many biochemical problems because its lifetime is too low. Compounds synthesized with this radioactive isotope become less active with time and hence less satisfactory from the standpoint of use as tracers. The carbon isotope of atomic weight 14 has a long lifetime and is very satisfactory as a tracer. Nevertheless, those people who have used the carbon-13 isotope for tracer work find it more convenient than the radioactive tracer. This may be due to greater experience in the handling of the stable tracer, though, of course, the reverse may be true in regard to those individuals who are acquainted with the methods of radioactive isotopic tracers. In particular, it appears that both carbon-14 and carbon-13 will have uses in biological experiments in which it is desired to identify different carbon atoms in a single molecule. Finally, it may be pointed out that deuterium or heavy hydrogen is a very useful tracer, the methods of analysis are not difficult, very adequate supplies are available,

and it does not suffer from the difficulty of radioactive contamination which may prove to be a problem in our chemical laboratories of the future.

Though the properties of the isotopes of an element are very similar indeed from a chemical standpoint so that their separation has proved to be an exceedingly difficult one, the differences in the nuclei of such isotopes are as different as those between the nuclei of different elements. Carbon-12 and carbon-13 or nitrogen-14 or nitrogen-15 differ in their nuclear properties as markedly as do carbon-12 and nitrogen-14, or carbon-13 and nitrogen-14, and this is generally true for isotopes throughout the periodic table. Uranium-235 is an explosive type of atom and uranium-238 is not; and protium differs from deuterium markedly in its reactions to neutrons. In connection with this remarkably interesting field of science which is unfolding at the present time, namely the structure and properties and reactions of atom nuclei, the separation of the isotopes of the elements will be of considerable importance.

A few years ago few people would not have thought that separated isotopes of any element would prove to be of outstanding importance, and even more recently we would not have suspected that the most important isotopes to separate were those of uranium. In the same way it is not possible for us to predict at the present time where the next important problem will arise. Always the great unknown reason is the most important for all scientific work.

PROBLEMS AND PROSPECTS IN ELEMENTARY PARTICLE RESEARCH

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(Read November 17, 1945, in the Symposium on Atomic Energy and its Implications)

ABSTRACT

Now that the broad principles of the science of nuclear transformations have become clear and this field has found important practical applications, it has become the task of science to explore the physics of the elementary particles. The purpose of this paper is to survey the outstanding problems and to discuss possible lines of investigation. Specific questions now at issue are: (1) the genetic relationship between the radiations found in nature—neutrons, protons, electrons, positrons, mesons, neutrinos, photons; (2) what possibilities exist for the transformation of one of these entities into another in the cosmic radiation and in stellar interiors; (3) what energies and intensities of bombardment are required to bring about appreciable numbers of these transformations; (4) which changes appear susceptible to study by artificial sources of high energy radiation now in prospect; (5) for which transformations does the cosmic radiation appear to be the only effective source which will be available for some time to come; (6) what can be done to make out of high altitude cosmic radiation a workaday source for elementary particle research; (7) what modifications are required in the field concept to describe gravitation, electromagnetism, the creation of electron-positron pairs and the forces between elementary particles in a unified manner, unambiguously and without divergences; (8) how stable are neutrons and protons, and what is the possibility to convert their entire mass into energy?

ON the second of December, 1942, Arthur Compton was speaking over the telephone wires to Washington. At the other end of the line James Bryant Conant had been waiting eagerly for news whether success would come in the search for a controlled nuclear chain reaction. He picked up his phone and heard a familiar voice say, "The Italian navigator has discovered America." "Splendid," was the answer: "and is the new country safe to enter?" "Yes," Compton's reply came back, "and Columbus finds the natives are friendly."

In the three years between that day and now the new territory has indeed proven friendly to our side in the war; and in these days after the war nuclear physics will play its part in the formation of the new world which has been the subject of the present inspiring discussions. But at the end of these discussions it is permitted to look beyond the rich Caribbean Islands which Columbus has invested to the great continent which lies beyond and which represents the last untraversed portion of knowledge of the physical universe.

The mathematicians of the days of the Renaissance navigator could believe through the errors of their calculations that he had completed the circuit of the globe. But for the unexplored world of physical science we have a measure of our distance travelled which is too simple to allow us similarly to delude ourselves about our progress, or the grandness of what is still before us.

The relation of Einstein between mass and energy is our sextant. It tells us that the most energetic nuclear transformation so far known, the fission of a heavy nucleus, releases only one part in a thousand of the energy which is locked up in its mass. It declares that not uranium alone, but all forms of matter, whatever they are, gram for gram, have the same intrinsic energy.

The untapped energy is to be found where the major part of the mass of the atom is located—in the nucleus. This structure as we now visualize it is a closely packed system of two kinds of particles, neutrons and protons, to which we give the common name of nucleons and—probably through our ignorance—the title of elementary particles. The energy of radioactivity and of nuclear fission comes from changes within the nucleus or divisions of the nucleus into parts in the course of which there occurs no alteration in the total number of nucleons present. The science of these nucleonic transformations in respect to heats of reaction and rates of reaction is now nearly as fully developed as chemistry itself. This is the science which underlies the atomic bomb and the pile. In contrast, we are concerned here with the question of ultranucleonic transformations in which the neutrons and protons are reduced to lower entities or altogether destroyed.

The possibility of the complete conversion of matter to energy is suggested by present incomplete information on the production of particles of lower mass by or from protons in the upper atmosphere of the earth.

Discovery how to release the untapped energy

on a reasonable scale might completely alter our economy and the basis of our military security. For this reason we owe special attention to the branches of ultranucleonics—cosmic-ray phenomena, the mechanism of energy production in special stars, field theory, and particle transformation physics—where a single development may produce such far-reaching changes. Other nations have not neglected this work during the war. We must prepare to resume it vigorously.

Before entering upon a program of expansion any progressive industry surveys the possibilities and decides what prospective lines of work promise the greatest dividends. Physics has never made such a conscious assessment of its problems. Possibly because of the individual character of original research, science has never possessed a central thinking agency. Possibly the closest approximation to such an institution has been Niels Bohr's Institute for Theoretical Physics in Copenhagen. Yet we need a comprehensive survey of the problems and prospects of elementary research most of all at this time when returning war scientists are planning their future research, when available scientific manpower is limited, when the problems of financial assistance have taken a new form, and when the importance of the last uncharted field of basic physics has become more apparent than ever before.

No such comprehensive survey is intended here. Your speaker, as one individual out of many, can only describe the problems that appear to him most deserving of attention. Another student of the subject might omit some topics, add others, or at least change the emphasis. Still, the differences between one reasonable list of outstanding questions and another are of little significance. The important matter is the completeness with which a few basic problems are investigated.

As we view the continent of ultranucleonic research from the island of nucleonics, we see as mountain peaks standing out against the horizon the five now known elementary particles and the four recognized kinds of interaction between them. Three of the particles are important in the constitution of atoms: the neutrons and protons which make up the nucleus, and the electrons which form the outer planetary structure of the atom, and whose mass is 1,800 times smaller than the mass of either of the nucleons. A fourth particle, the positron, is identical in mass with the electron but opposite in charge. The positron does not occur naturally on the earth because it possesses the property of combining with an electron to bring about annihilation of both particles. The fifth and most recently discovered entity, the meson, is found in the cosmic radiation with either sign of electric charge, and possesses a mass intermediate between that of a nucleon and an electron. The first observations led to a figure for the mass about two hundred times that of the electron,[1] but more recent and still preliminary experiments suggest the existence of several kinds of mesons with differing masses.[2] Mesons are found to disintegrate spontaneously with a characteristic life of the order of a few microseconds or less.[3]

To describe the forces which act between the elementary particles has so far required four types of interaction. Of these the oldest and most familiar is the gravitational attraction between every pair of masses. The second type of force, equally well verified by experience, is the electromagnetic interaction between elementary electric charges. Third is an interaction between nucleons which has been postulated to account for the stability of atomic nuclei. The properties of this specific nuclear force have been deduced in some detail from the properties of the known nuclei.[4] However, there exists no comprehensive theory of this interaction which can be claimed to be nearly so well founded as the theories of gravitation and electromagnetism. We cannot even exclude the possibility that our purely empirical description of the specific nuclear forces will find an interpretation in terms of a more fundamental type of interaction between elementary particles. The fourth and last mechanism which we recognize as a means for transferring energy and momentum from one system of elementary particles to another is a field of inter-

[1] These determinations of meson masses have been summarized by J. A. Wheeler and R. Ladenburg, *Phys. Rev.* **60**: 754, 1941.

[2] A reference to remarks by Schein on the existence of mesons of mass roughly equal to twenty electronic masses is made by H. Feshback and L. Tisza, *Phys. Rev.* **68**: 233, 1945.

[3] Montgomery, C. G., W. E. Ramsey, D. B. Cowie, and D. D. Montgomery, *Phys. Rev.* **56**: 635, 1939; Rasetti, F., *Phys. Rev.* **60**: 198, 1941; deSouza Santos, M. D., *Phys. Rev.* **62**: 178, 1942; Rossi, B., and N. Nereson, *Phys. Rev.* **62**: 417, 1942, Phys. Rev. **64**: 199, 1943.

[4] For the properties which must be attributed to the nuclear forces to give a representation of the experimental data, see Rarita, W., and J. Schwinger, *Phys. Rev.* **59**: 436 and 566, 1941; and Gerjuoy, E., and J. Schwinger, *Phys. Rev.* **61**: 138, 1942.

action to the quanta of which has been given the name of neutrinos.[5] The neutrino field transmits energy with the speed of light, as do the gravitational field and the electromagnetic field, and its quanta possess an intrinsic angular momentum equal to that of the electron.[6] Otherwise the properties of this fourth mode of interaction are imperfectly understood.

To make its way over the mountainous territory of research on the elementary particles and the basic interactions, physics must carry out three tasks: first, to make energetic particles available for workaday experimentation; second, to observe the changes which occur when matter is bombarded by such radiations; third, to reduce to the order of a consistent theory our knowledge of the genetic interrelations of the elementary particles and of the interactions between them.

Let us first consider the question what energies are required to produce ultranucleonic transformations and how these energies can be obtained. There appear to be two fairly distinct mileposts on the way to higher energies: one level of the order of 100 Mev (million electron volts) required for the creation of single mesons and another of the order 1 to 5 Bev (thousand million electron volts) necessary for the simultaneous production of as many as ten mesons in a single event.

The first milepost has already been reached by the induction accelerator of the General Electric Company at Schenectady.[7] This device uniformly accelerates electrons to an energy of 100 Mev and then allows them suddenly to be decelerated by impact on atomic nuclei. In the deceleration process quanta of electromagnetic radiation are produced with energies from 100 Mev on down. These radiative quanta are now available for the production of single mesons,[8] a phenemenon which before could only be observed in the cosmic radiation. By promoting the study of this process the induction accelerator promises to become the most important artificial source now in existence for the study of elementary particle transformations.

The energetic quanta of electromagnetic radiation which come from the induction accelerator also offer us for the first time an artificial source of neutrons with energies up to 50 Mev through the process of photoelectric dissociation of the heavy hydrogen nucleus, a system composed of one neutron and one proton. At the same time the mechanism of this dissociation process has recently acquired a certain additional interest of its own.

The idea has been advanced by Bhabha and Heitler,[9] and supported on tentative theoretical grounds by Wentzel,[10] that a nucleon is capable of existing not only in its normal form, as found in nature, but also in an unstable and short-lived state of higher energy and therefore of slightly greater mass. This prediction deserves our attention in the present connection chiefly because it suggests a significant experiment; for at the basis of the idea is a view of nuclear forces which must be considered at present to have only the character of a trial theory that has had so far a reasonable success in accounting for certain observed properties of light nuclei. With this qualification we may note that work of Wentzel and his collaborators on the basis of the theory in question leads to a value about 45 Mev for the energy of the excited state of a nucleon. If such a state exists, then the dissociation of a heavy hydrogen nucleus—which requires only 2 Mev of energy—by a 100 Mev quantum of radiation should give a neutron and proton which sometimes have a kinetic energy of 49 Mev each, and sometimes have only about 27 Mev each. From the given theory of nuclear forces Jauch and Lopez, in recent unpublished work,[11] estimate that the particles of lower energy should be one tenth as numerous as those of higher energy. A group of slower particles of such intensity should be observable with

[5] Fermi, E., *Ztschr. Physik* **88**: 161, 1934.

[6] Calorimetric measurements of the energy release in the beta transformation have been made by Ellis and Wooster, *Proc. Roy. Soc.* **A117**: 109, 1927 and Meitner and Orthmann, *Ztschr. Physik* **60**: 143, 1930. Check that the difference in energy between initial and final nucleus agrees with the upper limit of the spectrum comes from comparison of the $N^{13} - C^{13}$ mass difference, 1.21 ± 0.09 Mev, with the upper limit of the positron spectrum, 1.198 ± 0.006 Mev, measured by Lyman, *Phys. Rev.* **55**: 1123, 1939. Evidence for zero rest mass for the neutrino, and consequently a speed for this radiation equal to that of light, is presented by C. D. Ellis, *Int. Conf. of Phys., Proc.*, 53, London, 1934; published by the Physical Society, London 1935.

[7] Kerst, D. W., *Phys. Rev.* **60**: 47, 1941, *Rev. Sci. Inst.* **13**: 387, 1942; *Phys. Rev.* **68**: 233, 1945; Westendorp, W. F., and E. E. Charlton, *Jour. App. Phys.* **16**: 481 and 657, 1945.

[8] The results obtained in this direction are not yet available in published form.

[9] Heitler, W., and S. T. Ma, *Proc. Roy. Soc.* **A176**: 368, 1940; Bhabha, H. J., *Phys. Rev.* **59**: 100, 1941.

[10] Wentzel, G., *Helv. Phys. Acta* **13**: 269, 1940 and **18**: 430, 1945.

[11] This work of J. Jauch and J. Leite Lopez is being prepared for publication in the *Physical Review*. See also the Ph.D. thesis of Lopez, Princeton, Dec. 1945.

present techniques. Consequently, the 100 Mev radiation already available with the induction accelerator offers a means to detect the excited state of a nucleon if it exists.

Another order of magnitude of energy, 1 to 5 Bev, appears necessary if we are to observe the most striking type of ultranucleonic transformation now known, the sudden production in a single act of as many as ten mesons. Schein and collaborators, through balloon observations near the top of the atmosphere, discovered the existence of this phenomenon and the fact that it is brought about by single cosmic-ray particles, presumably protons.[12] The precise value of energy required for this process is in doubt. Only at the 5 Bev level does the cosmic-ray latitude effect appear to give reasonably reliable indirect evidence that the primary particles of the cosmic radiation produce multiple mesons. This figure might be considerably lower, perhaps as low as 1 Bev or 2 Bev, and would certainly be more precise if it had been possible on Millikan's high altitude balloon flights at Omaha, Bismarck, and Saskatoon [13] to carry aloft counter telescopes instead of electroscopes. The actual ambiguity in direction of entry of the particles through the magnetic field of the earth makes it necessary to adopt the conservative interpretation of the observations and the critical value of 5 Bev. Other experimental evidence, according to a personal communication of Schein,[14] suggests that the process of meson production by a cosmic-ray primary may still occur at 1 Bev, though with a low cross section.

There is another and less convincing way to arrive at a figure of the same order of magnitude for the second milepost of energy requirements in elementary particle research. For the impact between two nucleons to have an at all favorable chance to synthesize a third one it seems reasonable to assume that there should be available roughly 1.5 times the rest energy of the unborn nucleon, or perhaps 1.4 Bev. The nucleons of the target obviously being nearly at rest, it follows from the relativistic mechanics of the collision that the bombarding protons should have about 5 Bev of energy.

From these considerations of experiment and theory we conclude that there is an appreciable probability that we shall have to have particles in the billion electron volt range of energies in order to be able to observe the full variety of elementary particle transformations.

One means to reach this second milepost of energies is to construct artificial accelerators of a capacity which is much in excess of anything now available. Many principles of acceleration are known of which a few have been proved in practice, others are under active discussion, and some are to receive large scale tests in the next few years.[15] There is no doubt that it is technologically possible to reach billion volt levels.

A study of the problem leads, however, to the conclusion that the construction of devices to give energies as high as those we are considering here will probably be extremely expensive. The cost appears to be too great to be borne by any single university without outside assistance. If there are any scientific projects which deserve governmental support, this is one of them.

Even more costly than the money required to reach billion electron volt levels will be the drain on the country's research manpower if the development is done entirely by scientists. We do not have enough physicists in this country to be able to afford a large number of university groups working simultaneously on acceleration devices without any recognized division of labor between them. It would appear a more efficient use of our resources to have a first rate electrical engineering concern develop the source we need. On this plan the manpower would be drawn from the concern's own engineering staff. University scientists would be used only to suggest broad lines of attack and to act as consultants during the further progress of the work.

The drains against research funds and research manpower will both be relieved if the proposed National Science Foundation [16] of the Federal Government will let a contract to a qualified electrical concern to develop the accelerator. A first contract might cover design studies and reduced scale experiments. A favorable outcome of this work would then lead to a second contract for construction of a full sized unit for the Science Foundation to make billion volt particles available for general use by this country's scientists.

[12] Schein, M., W. P. Jesse, and E. O. Wollan, *Phys. Rev.* **59**: 930, 1941.

[13] Millikan, R. A., H. V. Neher, and W. H. Pickering, *Phys. Rev.* **61**: 397, 1942.

[14] Based on deductions drawn from the results presented by M. Schein, W. P. Jesse, and E. O. Wollan, *Phys. Rev.* **59**: 615, 1941.

[15] See for example McMillan, E. M., *Phys. Rev.* **68**: 143 and 144, 1945, and Veksler, V., *Jour. Phys. U.S.S.R.* **9**: 153, 1945.

[16] Bush, V., *Science, the endless frontier*, Washington, U. S. Government Printing Office, July 1945.

Whether this national source were the only laboratory supply of particles of extremely high energy would then depend entirely upon the cost of subsequent units of the same character, freed of all the cost of developmental work.

However done, it is reasonable to believe that an accelerator of protons for the billion electron volt range must and will be built.

A second source of very energetic particles is the cosmic radiation itself. This natural source and the artificial sources which we have discussed both have their own characteristic advantages. Neither can take the place of the other. One supplies high intensity, reproducible energy, well-defined timing. The other not only provides a wealth of phenomena which so far has been explored only in part but also offers for experimentation particles with energies ranging all the way from the billion electron volt level up to energies at least as great as 10^{17} electron volts,[17] a figure not likely soon to be duplicated in the laboratory. Cosmic rays are available now, while the accelerator which we have discussed is probably several years away. When we consider the wonderful advances made by Rutherford and his collaborators in nuclear physics with sources separated out of the minerals of the earth, and then note that for ultranucleonic research also this globe is supplied with particles of the necessary energy, we marvel at the richness of nature.

The cosmic radiation must be made into a workaday source for elementary particle research. It is impractical for large numbers of scientists to go to remote mountain peaks to carry out their investigations. Effective work calls for heavy equipment, high altitudes, long observations, yet close and continuous association with a research center.

Is there a practical means to meet these conditions? To analyze from the point of view of this question the ingenious expedients which have so far made it possible to learn so much about the cosmic radiation would be out of place here—their story is too extensive [18] and deserves to be told separately. From a study of these methods, however, it is apparent that there is one means of great promise for making the cosmic radiation an effective research tool—the postwar use of military planes.

Transportation of experimental equipment weighing as much as ten tons on regular schedules to altitudes between 30,000 and 40,000 feet from flying fields no more than fifty miles from research centers is the kind of program under which one or other of the armed services can make a substantial contribution to fundamental science. Research money would in this way be freed for research itself, and for research of a most effective kind. It is to be hoped that such an arrangement will materialize.[19]

Whether made more accessible by such an airplane program or by other means, the cosmic radiation is destined to increase in usefulness as a tool in fundamental particle research.

Our survey of the means which we must develop to get swift particles for ultranucleonic research has ended with our viewing the cosmic radiation in the light of a research tool. However, the nature and source of this radiation are also matters of interest in their own right.

We are not at all certain that the complete duplication of cosmic-ray phenomena requires only the bombardment of matter with protons of sufficiently great energy. We must be prepared for the possibility of surprises about the composition of the cosmic radiation. In this connection it should be noted that Klein[20] and Arley [21] have recently investigated seriously the consequences of the hypothesis that a portion of the radiation striking the earth contains negative protons. These particles are of a type so far not known to experiment, but are postulated to be capable of annihilating the positive protons found on earth with the creation of quanta of electromagnetic radiation or of mesons. Klein points out that the proposed negative protons permit the existence of a form of matter identical with that found on earth except for a complete reversal of sign

[17] Evidence for cosmic-ray events with energies in the range 10^{16} to 10^{18} ev has been presented by A. Alichanian, T. Asatiani, and A. Alexandrian, *Jour. Phys. U.S.S.R.*, **9**: 148, 1945; Lapp, R. E., *Phys. Rev.* **64**: 129, 1943; Lewis, L. G., *Phys. Rev.* **67**: 228, 1945; and Wolfenstein, L., *Phys. Rev.* **67**: 238, 1945.

[18] Such an account would include balloon flights, establishment of high altitude cosmic-ray observing posts, making measurements in mines and lakes, exposure of photographic plates to cosmic rays, and development of new techniques for the detection of ionizing particles.

[19] Significant results have been obtained by H. J. Bhabha, S. V. C. Aiya, H. E. Hoteko, and R. C. Saxena, *Phys. Rev.* **68**: 147, 1945 in cosmic-ray flights over India carried out by the 84th Air Depot of the U. S. Army Air Force.

[20] Klein, *Ark. f. Mat. Ast. och Fys.* **31A**, no. 14, 1945.

[21] Arley, N., *Kgl. Danske Vid. Sels. Math. Phys. Medd.* **23**, no. 7, 1945. This article gives an instructive review of cosmic ray experiments as they especially bear on the problem of the charge and nature of the primary radiation.

of charges. He supposes that many atoms of this reversed form of matter may enter the earth's atmosphere at one time in the form of a particle of interstellar dust, and by nearly simultaneous annihilation account for a very great energy release. The annihilation of a single pair of negative and positive protons would give off an energy of only 1.8 Bev, but the hypothesis that part of the incoming radiation consists of dust particles of the postulated character would seem to make it possible to account for the release of energies as great as the 10^{17} electron volts already observed. Of course this line of reasoning does not free one of the necessity to explain how a single charged particle can acquire the energy of the order of 10^{12} electron volts required to penetrate to a mine tunnel a mile below ground.[22] Nevertheless, whatever objection one may raise against the proposed hypothesis, the fact that it can be discussed seriously by well qualified physicists shows how much we have to learn about the nature of the cosmic radiation.

Our consideration of the ideas of Klein and Arley serves to emphasize the valuable distinction which must be maintained, at least until we know more, between (*a*) the total kinetic energy of a cosmic-ray primary (*b*) the kinetic energy per nucleon of this cosmic-ray primary and (*c*) the sum of this kinetic energy and of the rest energy which will be set free if the nucleon is destroyed by impact or annihilated by combination with another particle. We do not have to postulate the existence of a reversed form of matter to raise the question whether the more energetic cosmic-ray events are not initiated by large atoms or especially by dust particles composed of many atoms. It is especially appropriate to note this question at a time when no satisfactory account has been found for the anomalously narrow and intense cores observed at the centers of extensive cosmic-ray showers.[23]

Passing from the problem of the nature of the cosmic rays to the question of where they get their energy, we have to recognize that much remains to be done before we can exclude the existence of a straightforward mechanism of acceleration of charged particles in interstellar space, by electric fields maintained through some yet-to-be discovered combination of well known phenomena in physics and astrophysics. An example of such a phenomenon is radiation pressure. By this process the sun can impart to a dust particle with dimensions of the order of 10^{-5} cm a kinetic energy sufficient to carry an elementary positive charge of electricity through a potential rise of the order of 10^{13} volts. A continual flow of such macroscopic charged particles caused either by radiation pressure or by ejection of matter from stars would, of course, be capable of maintaining indefinitely a non-equilibrium distribution of electric charge in the galaxy. In the field generated by such a charge distribution it is possible that an atom or dust particle, becoming charged by photoelectric effect or otherwise, will describe a motion of quasi-ergodic character. Observations made near a chosen point in space of many particles undergoing motions of this type will disclose nearly uniform distribution of particles in direction, almost complete obliteration of any features in the distribution which might recall the dependence upon position of the accelerating electric field. In this connection one will naturally recall the striking constancy of primary cosmic-ray intensity as the earth rotates.

It would be out of place here to stress any further these purely illustrative considerations. However, a few more remarks may be made. First, the sharpness of the absorption lines of clouds of interstellar calcium ions as observed by Hartmann, Pearce, and Adams[24] tells us that there are some regions in space where great potential differences must *not* be assumed to be present. Second, the assumption that all the cosmic-ray particles carry positive electricity leads to a space charge sufficient to produce a potential difference of 10^{20} volts in a distance of 5 light years, the radius of the domain of the average star in our own portion of the Milky Way. Third, active investigations are now in progress [25] in several ob-

[22] Wilson, V. C., *Phys. Rev.* **53**: 337, 1938; and **55**: 6, 1939.

[23] Evidence for cores of high density in cosmic-ray showers has been presented by L. G. Lewis, *Phys. Rev.* 67, 228, 1945, by A. Alichanian and T. Asatiani, *Jour. Phys. U.S.S.R.* **9**: 55 and 175, 1945 and by G. Wataghin, M. D. deSouza Santos, and P. A. Pompeia, *Phys. Rev.* 57: 61 and 339, 1940.

[24] Hartmann, *Astrophys. Jour.* **19**: 268, 1904; Plaskett and Pearce, *Dominion Astrophys. Obs. (Victoria)*, Pub. **5**: 1 and 99, 1935; Adams, *Astrophys. Jour.* **97**: 105, 1937. A recent review of the question of the material of interstellar space has been presented by C. S. Beals, *Popular Astron.* **52**: 209, 1944. The author is indebted to Dr. J. A. Pearce and to Professor H. N. Russell for discussions of this question.

[25] A survey of the problem of material in interstellar space, including evidence on the amount and nature of dust particles, has been given by T. Dunham, Jr., *Proc. Amer. Philos. Soc.* **81**: 277–293, 1939. Other recent papers on

servatories on the roles of interstellar dust as intermediate step in the process of condensation of molecules, as interceptor of radiation, and as carrier of electricity. In view of the rapid developments in this field it would be a bold person who would say that the origin of the cosmic radiation is not to be explained within the framework of present astrophysical concepts.

Whether physics gets the particles for elementary corpuscle research from the cosmic radiation or from artificial accelerators, its second great task is to observe the transformations initiated when these particles strike matter. It is convenient to discuss these changes in order, with those we know least about last.

The transformation processes best studied, both theoretically and experimentally, are those in which electrons, positrons, and electromagnetic fields play a part, with atomic nuclei acting at most as catalyzers. The laws governing (1) the creation of pairs of electrons and positrons by radiation and (2) the deceleration of pair particles with the production of more radiation [26] have almost passed from the role of matters to be checked experimentally on their own account to the position of well-proven tools in the investigation of the cosmic radiation as a whole. To explain the properties of the soft or lead-absorbable component of this radiation in terms of the two mechanisms just mentioned was a great triumph of the theory of pairs.[27] Some other consequences of this theory remain to be investigated experimentally—for example, the deduction that the annihilation of a slow positron by an electron results in the emission of two quanta of radiation whose planes of polarization are oriented at a right angle to each other, and the prediction that there exist short-lived entities composed of approximately equal numbers of electrons and positrons.[28] To test experimentally these and other predictions will increase our knowledge of the foundations of electron-positron physics.

A second class of transformation requiring further investigation comprises the nucleonic changes which occur in the atmosphere under cosmic-ray bombardment: the absorption of energetic quanta of radiation in atomic nuclei to produce nuclear explosions, the so-called stars found on photographic plates exposed to the cosmic radiation; the emission from these stars of fast neutrons and protons; and the moderation of the energy of the neutrons by elastic collisions with oxygen and nitrogen nuclei to produce slow neutrons.[29] Previous experimental and theoretical work has established that the numbers of quanta, of stars, of fast protons and neutrons vary together with altitude in the lower part of the atmosphere as would be expected from the mechanisms just mentioned. Important problems remaining for investigation are (1) the extension of measurements to higher altitudes to determine whether any neutrons are present in the primary radiation; (2) investigation whether the main part of the primary radiation has any star-producing components of its own; (3) determination with what power of the quantum energy of the radiation does the cross-section for nuclear explosions increase, and for what energies does this increase come to an end;[30] (4) investigation whether any entities other than quanta of radiation contribute significantly at moderate altitudes to the production of nuclear explosions; (5) the correlation of the number and energy of the particles ejected in such an explosion with the energy of the star-producing radiation; (6) the closer analysis of the correlation between slow and fast neutrons to determine whether this aspect of the subject is fully in order. It will be necessary to carry through a thorough investigation of these nucleonic processes which take place in the cosmic radiation before we can be certain that in this connection we do not sometimes have to deal

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interstellar dust are: Spitzer, L., Jr., *Astrophys. Jour.* **93**: 369, 1941; **94**: 232, 1941; **95**: 329, 1942; ter Haar, D., *Astrophys. Jour.* **100**: 288, 1944; Schalen, C., and G. Wernberg, *Arkiv Matematik. Ast. och Fysik* **27A**, no. 26, 1941; see also the review by Beals in reference 24.

[26] The calculations of the cross sections for pair production and for radiative deceleration of electrons are reviewed, and references to the original literature are given, in the book of W. Heitler, *The quantum theory of radiation*, Oxford, Clarendon Press, 1936.

[27] The explanation of the soft component of the cosmic radiation in terms of pair production and radiative deceleration was given independently by H. J. Bhabha and W. Heitler, *Proc. Roy. Soc. London* **A159**: 432, 1937; and by J. F. Carlson and J. R. Oppenheimer, *Phys. Rev.* **51**: 220, 1937.

[28] A further discussion of the polarization problem and of the properties of systems composed of electrons and positrons is contained in a paper by the author which has been submitted for publication by the New York Academy of Sciences.

[29] For a general review of the question of these nucleonic transformations in the cosmic radiation, see the section by E. Bagge in the book, *Kosmische Strahlung*, ed. by W. Heisenberg, Berlin, Springer, 1943.

[30] In connection with the experimental problem of frequency dependence of the nuclear cross section attention should be called to the theoretical considerations of V Weisskopf, *Phys. Rev.* **59**: 318, 1941.

with unsuspected ultranucleonic transformations.

A third and much more difficult problem of transformation physics is to extend the range of our experience about the changes in which neutrinos take part. We already possess a wealth of experimental information about the process of emission of neutrinos, mostly from the radioactive decay of atomic nuclei,[31] but also partly from the disintegration of mesons.[32] However, other processes in which neutrinos take a part, whether of absorption or of scattering, are so far altogether unknown to us.[33] Certain processes of absorption of neutrinos by atomic nuclei, accompanied by simultaneous nuclear absorption or emission of an orbital electron, can of course be predicted from the available observational data with the aid of the principle of microscopic reversibility. The effective cross section presented by a nucleus for the interception of neutrinos by such a mechanism is so small that this process is yet unobserved. Moreover, if this cross section were large enough to be conveniently observable, then there would be a direct violation of the principle of microscopic reversibility which allows a straightforward calculation of the quantity in question from measured values of radioactive decay constants.[34] The very fact that the cross section for the process inverse to radioactive decay is subject to calculation tells us that we have to look for transformations of another character if experimental knowledge of the interaction of neutrinos with matter is substantially to be extended. There is no indication that means of detection and strength of neutrino sources have at all approached a power sufficient to allow such an extension of our knowledge at this time.

The fourth and last major field of experimental transformation physics, and the field apparently much the richest in promise, is investigation of the creation, destruction, and properties of mesons. These particles are well suited to experimental investigation, for they account for approximately three quarters of the total cosmic-ray intensity observed at sea level, roughly one particle per square centimeter per second. At the same time the mesons have a substantial theoretical interest because their masses, intermediate between those of an electron and a nucleon, raise our hopes someday to find the so far undiscovered genetic relationship between these two particles.

Some important questions present themselves about the mechanism of production of mesons: (1) what is the energetic threshold for production of a single meson by a quantum of radiation; (2) how does the probability of production of a meson of any given mass vary as the energy of the radiation is increased above the threshold for creation of particles of that mass; (3) what are the relative probabilities for the creation of positive and negative mesons; (4) how do these probabilities vary with the atomic number of the nucleus in whose neighborhood the radiative production of mesons takes place; (5) are any changes produced in the nucleus itself by the process of meson synthesis; (6) what is the angular distribution of the mesons relative to the direction of the quanta of radiation; (7) are sufficiently energetic quanta of radiation capable of multiple meson production, a process that has so far appeared to require for its initiation those ionizing particles which are found most frequently near the top of the atmosphere and which are often considered

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[31] See the review of the subject of beta-decay given by E. J. Konopinski, *Rev. Mod. Phys.* **15**: 209, 1943.

[32] One cloud chamber photograph of the ending of a meson track and the emission of an energetic decay electron from it has been published by E. J. Williams and G. E. Roberts, *Nature* **145**: 102, 1940, and another by R. P. Shutt, S. DeBenedetti, and T. H. Johnson, *Phys. Rev.* **62**: 552, 1942. The emission of a neutrino in the direction opposite to the decay electron is inferred from the law of conservation of momentum and from a comparison of the intensities of soft and hard components of the cosmic radiation: L. W. Nordheim, *Phys. Rev.* **59**: 554, 1941.

[33] Evidence against appreciable absorption of neutrinos has been presented by Chadwick and Lea, *Proc. Camb. Phil. Soc.* **30**: 59, 1934 and by M. E. Nahmias, *Proc. Camb. Phil. Soc.* **31**: 99, 1935.

[34] The cross section for induction of beta ray emission by neutrino bombardment has been calculated by H. A. Bethe and R. F. Bacher, *Rev. Mod. Phys.* **8**: 198, 1936; see also Peierls and Bethe, *Nature,* **133**: 532, 1934. Among the theoretically predictable processes of neutrino absorption there is one for which the calculated absorption probability takes a relatively favorable value. This mechanism is the reverse of a special and rarely recognized type of beta transformation. This transformation produces the discrete spectrum which lies at the limit of the usual continuous spectrum. The decay electron is emitted by the nucleus into a stable electronic state of the atom. The outgoing neutrinos have a line spectrum. For the inverse neutrino absorption process the cross section of the stable atom has a value of the order of magnitude of the square of the neutrino wave length. The width of this resonance absorption line is of course exceedingly narrow, being given by the product of the quantum of angular momentum and the partial decay constant of the radio-active atom for the special type of beta emission process just mentioned.

to be protons;[35] (8) what additional evidence can be obtained about the character of those primary cosmic-ray particles which on impact with a thin target produce a number of mesons, apparently in a single act;[36] (9) can one exclude the possibility that these entities are heavy atoms or dust particles, many nucleons of which simultaneously make collisions with the nucleons of the target; (10) what is the relative contribution of single and multiple production processes to the observed meson intensity; (11) which type of process contributes most to the 20 per cent excess of positive over negative mesons observed at sea level;[37] (12) is there any evidence of the destruction of nucleons in any of the acts in which mesons are created?

These problems about the mechanism of production of mesons lead us to equally interesting questions about the properties of this entity: (1) with what masses may mesons exist; (2) is the radioactive life of a meson uniquely fixed by its mass; (3) does the life time vary in a substantial way between mesons of different masses; (4) is it possible to establish the existence of those mesons which are sometimes postulated[38] to exist with a characteristic life several orders of magnitude shorter than the value, about two microseconds, found for the great majority of the mesons which reach sea level;[39] (5) does the radioactive decay of a meson always take place by division into[40] an electron or positron and a neutrino; (6) is the scattering and radiative deceleration of mesons by atomic nuclei in satisfactory accord with theory; (7) is there any evidence for the existence of neutral mesons?

Finally the mesons present us with the important question of possible modes of destruction other than simple radioactive decay: (1) can confirmation be obtained for preliminary indications[41] that roughly half of the mesons whose energies are moderated in solid bodies undergo capture; (2) are negative mesons captured by atomic nuclei; and, if so, is the capture cross section a selective or a smoothly varying function of atomic number; (3) is radiative capture into a Bohr orbit ever a preliminary to complete absorption of a meson; (4) do positive mesons capture electrons; (5) if either type of capture process takes place, what are the end products of the reaction?

With this list of questions we conclude our brief review of some of the outstanding experimental problems in elementary particle physics—problems concerned with electrons and positrons, nuclear explosions, neutrino physics, and most of all with the meson. The brevity of the questions does not conceal their difficulty. Still, physical science, if it has performed properly its first task of making sources of high energy particles available for workaday experimentation, will find greatly eased this second task of investigating elementary particle transformations to extend the range of our experience.

The other great task of fundamental physics is the reduction to order of our newly gained experience. This theoretical work must proceed hand in hand with experiment for the most effective progress if the history of physics is any guide. Only by the analysis and interpretation of observations as they are made, and the examination of the larger implications of the results, is one in a satisfactory position to pose new experimental and theoretical questions of the greatest significance. That two research projects involving the same expenditure of time and manpower often give results whose importance differs by a factor over a hundred is sometimes a matter of accident. But more often it is a matter of greater awareness in one project of what are the most significant questions susceptible at the moment to successful attack. This continual assessment of results of investigations and of choice of further problems in the light of the outstanding unsolved questions is essential in elementary particle physics. No branch of science can derive greater advantages

[35] For indications that the cosmic radiation may consist of protons, see Johnson, T. H., *Rev. Mod. Phys.* **11**: 208, 1939 and Schein, M., W. P. Jesse, and E. O. Wollan, *Phys. Rev.* **57**: 847, 1940 as well as the book *Kosmische Strahlung* edited by W. Heisenberg, Berlin, Springer, 1943.

[36] See Schein, M., W. P. Jesse, and E. O. Wollan, *Phys. Rev.* **59**: 930, 1941.

[37] Jones, H., *Rev. Mod. Phys.* **11**: 235, 1939; Hughes, D. J., *Phys. Rev.* **57**: 592, 1940.

[38] The existence of very short-lived mesons was proposed by C. Møller and L. Rosenfeld, *Kgl. Danske Vid. Sels. Math. Fys. Medd.* **17**, 1940; and their relation to experiment has been considered by Hamilton, Heitler, and Peng, *Phys. Rev.* **64**: 78, 1943.

[39] See reference 3.

[40] For evidence for the division of a decaying meson into an electron and a neutrino, see reference 32.

[41] See Conversi, M., E. Pancini, and O. Piccioni, *Phys. Rev.* **68**: 232, 1945, for a review of evidence that roughly only one half the mesons stopped in a solid matter undergo decay, and for experimental evidence of their own that the majority of these decay processes are due to positive mesons, in accordance with predictions of S. Tomonaga and G. Araki, *Phys. Rev.* **58**: 90, 1940.

from review articles, survey lectures, the library, and the seminar.

The task of reducing our experience to order includes not only this close collaboration of theory with experiment but also the creative function to assimilate the fruits of such collaboration into a unified view of matter.

The theories by the creation of which science accomplishes this function of unification are always idealizations, valid within a certain domain of experience, and inapplicable outside. A large part of our physical experience is now summarized in a few great and well founded theories: the theory of relativity,[42] the theory of gravitation of Mach and Einstein,[43] electromagnetism,[44] the quantum theory typified by Bohr's contrasting principles of complementarity and of correspondence,[45] and the theory of electron-positron pairs.[46] Taken within their proper fields of application these theories offer a solid basis for our further theoretical progress. The work for the future appears to be the union of the several points of view of these theories and the assimilation into all of them of certain limitations on our usual concepts which are imposed by the existence in nature of elementary particles. It seems reasonable to suppose that our further advance will depend less upon the invention of new laws of force and types of interaction than upon renewed analysis of the fundamental problems of measurement and observability along the lines of the classical paper of Bohr and Rosenfeld on the measurability of the electromagnetic field quantities.[47]

[42] For a general account of the relativity theory see W. Pauli's article, "Relativitätstheorie," in *Encycklopädie der mathematischen Wissenschaften*, ed. by A. Sommerfeld, V (2), issue 4, art. 19, Leipzig, Teubner, Sept. 15, 1921.

[43] For a recent survey of the status of the relativity theory, see Einstein, A., *The meaning of relativity*, Princeton Univ. Press, 1945. See also Einstein, A., L. Infeld, and B. Hoffmann, *Ann. Math.* **39**: 65, 1938, for a discussion of the relation between the equations of motion of the particles and the field equations.

[44] See for example the presentation of M. Abraham and R. Becker, *The classical theory of electricity and magnetism*, London and Glasgow, Blackie and Sons, 1932.

[45] For a discussion of general principles, see Bohr, N., *Atomic theory and the description of nature*, Cambridge Univ. Press, 1934, especially p. 10 where the principle of complementarity is briefly stated.

[46] Dirac, P. A. M., *Proc. Camb. Phil. Soc.* **30**: 150, 1933; Heisenberg, W., *Ztschr. Physik* **90**: 209, 1934; Weisskopf, V., *Kgl. Dansk. Vid. Sels. Math. Fys. Medd.* **14**, no. 6, 1936.

[47] Bohr, N., and L. Rosenfeld, *Det. Kgl. Dansk. Vid. Sels. Math. Fys. Medd.* **12**, no. 8, 1933.

It may give an impression of the task of elementary particle physics in the realm of theory to review briefly some of the problems of the theory of mesons, of the electron-positron pair theory, of electromagnetism, and of the theory of gravitation.

The first topic, the theory of mesons, may be said to be at present in a state of free experimentation with ideas and great uncertainty as to principle, both because of the incompleteness of our present experimental picture, and because of difficulty in tying the proposed hypotheses to already existing theories. As a guide in these attempts, the assumption has been adopted[48] that mesons should play in the interaction between nucleons a role analagous to that of quanta of electromagnetic radiation in the interaction between charged particles. Some appreciable success has been achieved along these lines in giving a half theoretical, half empirical account of the most important features of the nuclear forces.[49] All such theories have however so far failed to give an at all reasonable quantitative account of the magnetic moment of the proton and the neutron, or of the phenomenon of radioactive decay of mesons and nucleons. Without attempting to prejudge the reasonableness of such theories, we must of course recognize that the initial assumption about the existence of a meson field is only an assumption. In contrast it is quite conceivable that anything but a purely phenomonological description of the interactions of mesons and of nucleons will be excluded until we shall have learned to understand the genetic relationships between the elementary particles.

The difficulties of inventing a new theory on the basis of incomplete experimental evidence suggest that one possibility acceptable at this time is the conservative one of extending the range of applicability of already existing and well-established theories.

The second theory whose problems we consider

[48] Before the existence of the meson was recognized experimentally the possibility of a similar explanation of the nuclear forces in terms of an electron-neutrino field was first proposed in 1934 lectures by Heisenberg, according to H. A. Bethe and R. F. Bacher, *Rev. Mod. Phys.* **8**: 201, 1936. The proposal of particles of intermediate mass was first published and worked out in detail by H Yukawa, *Phys. Math. Soc. Japan* **17**: 48, 1935, and led to recognition of the existence for such particles in the cosmic radiation.

[49] See reference 11 for citations to the literature of applications of the existing forms of meson theory.

is therefore the formalism of electron-positron pairs.[50] This theory has already shown itself comparable in unity, comprehensiveness, and richness of application to the classical theories of gravitation and electromagnetism. Its contribution to the understanding of the soft component of the cosmic radiation has already been mentioned. It has made well-verified predictions about other collision processes. However, there are certain problems in this theory which so far have been analyzed only imperfectly: for example, the state of the electron-positron field in the neighborhood of an atomic nucleus, the spin-spin interaction of a positron and electron bound together in a hydrogen-like structure, the effect of the electron-positron field on the scattering of one electron by another.

The boundaries of the present applications of the pair theory correspond to the limitations of its formalism. The mathematical framework is at present not adapted to taking into account the interactions of the particles of the electron-positron field with one another. We must develop a mathematical and conceptual scheme adapted to handling these questions. If there are any elementary particles about the quantum theory of which we know enough to begin to set up a reasonable formalism, these particles are certainly the electron and positron. Solution of the problem in this case should give us a model after which possibly to pattern the description of other elementary particles.

The third theory we shall discuss briefly is the classical theory of electromagnetism. This theory in its usual form appears to contain within itself those difficulties of the infinite energy of interaction of a point charge with itself and of an infinite number of degrees of freedom for the field quantities which, upon translation into the quantum theory of fields, cause two characteristic types of mathematical divergence.[51] For a time it was supposed that these divergences implied a fundamental failure of quantum mechanics. More recently a program has developed to remove the divergences by a reexamination and redefinition of the role of the field concept in the underlying classical theory.[52] The general tendency of this program is to regard the fields purely as mathematical intermediaries used to describe the interaction at a distance between point charges. The infinite number of degrees of freedom are in this way attributed to the particles themselves; and the imposition of certain regularity conditions on the motions of the particles appears to remove altogether this infinitude of degrees of freedom. This theoretical development, still in progress, follows the conservative line of elucidation of existing theory which we have already mentioned. It is too soon to say whether the translation of the revised classical theory into quantum mechanics will remove the outstanding divergences. To test this point is an important problem for the future.

The last theory to be mentioned, gravitation, is in a state quite comparable to that of electromagnetism, for the usual mode of description in both theories assumes a continuous distribution of mass and charge and the possibility of an unlimited number of test particles in contrast to the atomistic distribution implied by the existence of elementary particles. Just as the proper recognition of this atomicity requires in the electromagnetic theory a modification in the use of the field concept equivalent to the introduction of the concept of action at a distance, so it would appear that in the gravitational theory we should be able in principle to dispense with the concepts of space and time and take as the basis of our description of nature the elementary concepts of world line and light cone. By a further development of this line of reasoning we may hope to resolve some of the apparent paradoxes which are encountered when we find that we can apply the present gravitional field equations to the idealized problem of two point masses in otherwise empty space.[53] We may hope at the

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[50] See reference 46.

[51] Some of the problems of divergence in the existing quantum electrodynamics are discussed in the book of W. Heitler, *The quantum theory of radiation*, chap. III, Oxford, Clarendon Press, 1936. See also Heisenberg, W., *Ber. Sächs. Akad. Wiss. Leipzig, Math. Phys. Kl.* **83**, 1931.

[52] In connection with attempts to solve the divergence problems of electromagnetic theory, see Dirac, P. A. M., *Comm. Dublin Inst. Adv. Studies*, Series A, no. 1, 1943. A different approach is to look for a solution of some of these problems in a closer elucidation of the role of the field concept in the underlying classical theory itself; see for example Wheeler, J. A., and R. P. Feynman, *Rev. Mod. Phys.* **17**: 157, 1945.

[53] For the solution in question see Einstein, A., and W. Mayer, *Preuss. Akad. Wiss. Sitzber., Phys. Math. Klasse* **111**, 1930. See also Weyl, H., *Ann. Physik* **54**: 117, 1917, and an appendix by H. Weyl in the paper of R. Bach, *Math. Ztschr.* **13**: 134, 1922. For the general question of compatability of the present gravitational theory as represented by the two mass problem with the basic idea of Ernst Mach that the inertia of a given particle is determined by the distribution of matter in the

same time to get a more comprehensive view than we now possess of what types of interaction might reasonably be expected to occur in a classical description of nature.

From this survey of some of the problems of theory it is apparent that many lines of progress are open. Elementary particle physics will accomplish its task to reduce our experience to order just as it will get sources of energetic particles and use these sources to study the transformations of the elementary particles. The achievement of all these tasks together will carry us over the last mountain peak of the continent of ultranucleonics. Then we shall see the whole rich new land spread out beneath us.

Shall we ask at the end of the journey what is the good of this new continent? Shall we inquire what it will profit us to know how the universe is put together? Who will it be who can decide so soon the future uses of this new land? That will be the work of those who will come next.

But, if at the moment when the far shore shall be reached and before the days of colonization shall have begun the world shall ask what are the most precious immediate assets at its disposal from this exploration, we know now from the experience of the past war what the answer will be. We have only to recall the essential role played in all parts of the war effort, far from their own specialties, by men trained in fundamental science, to realize that we should look for the answer, not at the gold which will be brought back from the great adventure, but at the band of explorers themselves.

On men like these searchers will depend our future in war and in peace. They will make for us new tools of defense in days of danger. They will leaven our applied science, our technology, our industry, and our intellectual life in the days of peace. Their qualities of mind and heart are the prize.

We must seek out our able young men, outfit them, and send them forward to work their way through the unknown, not only because the land is rich, but most of all because only participation in this great Odyssey will develop men of the kind on whom our future as a nation depends. There is no other way.

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rest of the universe, see the dialog of H. Weyl, *Massenträgheit und Kosmos* in his collection *Was ist Materie?* Berlin, Springer, 1924, the discussion by Einstein in the new section of his book cited in reference 43, as well as E. Mach himself, *The science of mechanics* (trans. from 2nd German ed.) 229–237 and 511–516, Chicago, Open Court, 1893.

SOCIAL ADJUSTMENTS TO ATOMIC ENERGY

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(Read November 16, 1945, in the Symposium on Atomic Energy and its Implications)

A SOCIAL scientist who contemplates the technical achievement involved in the release of atomic energy feels a deep respect for a professional achievement. I am not an authority on the history of science, but I doubt whether that long and amazing history contains anything that compares with the effective victory over the unknown that the scientists of atomic physics have won. Certainly, nothing could be as dramatic as the final culmination of that fifty years of work. Nothing that I may say later about social consequences of atomic bombs and atomic energy will gainsay for a minute the humble respect I feel for this successful attainment of scientific and technological objectives.

The history of inventions shows that at the time of a particular discovery the social effects to come from that invention can only be judged as the size of an iceberg is judged with seven-eighths of its whole below the surface of visibility. Natural scientists have as yet provided us very little of the essential concrete information on atomic energy; so a social scientist who comments on the social implications of atomic energy cannot speak about results but only about the process of social adjustment to the changes, present and prospective, set in motion by the release of that energy. To facilitate such a discussion, I state dogmatically a series of assumptions. They may be true, or they may be false. But they constitute the foundation for my remarks:

1. There is no foreseeable effective defense against atomic bombs.
2. Not secrecy, nor cost, nor lack of materials will prevent bombs from being available to many countries within a few years.
3. The armament race in atomic bombs is already under way.
4. Atomic bombs may decrease the likelihood of war, but, if war starts, the eventual use of atomic weapons should be assumed.
5. The ultimate military position of the United States may have been weakened rather than strengthened by the discovery of atomic bombs.
6. A world of atomic bombs puts a democratic regime at a disadvantage with a totalitarian one.
7. There is no present practicable way of guaranteeing peace. However, the multitude of forces which make for peace can be strengthened.
8. Neither expectation of a sudden moral regeneration of mankind nor a magic formula for sudden world government offers as much hope for peace as patient working through established agencies, international and national.
9. Full support of UNO is indicated.
10. No international machinery can be an effective substitute for a wisely oriented and skillfully manipulated foreign policy with other nations.
11. The penalties for stupid and malevolent action are enormously increased; and likewise the incentives for wise and virtuous conduct are more imperative.
12. Production, on a laboratory basis, of power from atomic fission is here; it would be wise to assume that its commercial development is only a matter of time and degree.
13. Attention should be focussed, not exclusively on the social implications of atomic bombs, or of atomic energy, but on the entire accelerating advance of the physical and biological sciences and the technology which will produce even more titanic powers for man to use or abuse.
14. No social "atomic bomb" can be produced by social students to neutralize the atomic bomb or any other scientific weapon.

This last assumption is true and the basic one on which to start discussion. No unitary, mechanistic answer on the social side is possible. It is strange how many intelligent people are wedded to the idea that problems which lie in the social behavior of volitional human beings should respond to a mechanistic solution. The process of social adjustment, in a democratic society especially, ordinarily involves four steps:

1. Growth of a broad public awareness of the problem. On today's subject it is fair to say that our democracy is "rolling." If there is any general group today that is not discussing atomic bombs I have not heard of it. This "awareness" is a necessary pre-condition of wise action; but it alone does not guarantee wise action. It can lead to foolish or malevolent consequences unless supplemented by the three other steps:

2. Scientific and scholarly analysis of the facts, processes and issues. This means, in the issues of atomic energy, a wide opportunity for collaboration between natural scientists and social scientists.

3. The development of competent experts—scientific and administrative.

4. Integration of the results of scientific studies and public sentiments and interests into wise public policies. This isn't our national forte!

Given these preliminaries, I will comment on four areas where the social adjustments to atomic energy are critically important. There is a wide general awareness of the social issues in the first two: (1) international relations; (2) commercial power. The issues created in the other two have received much less attention. These are: (3) politics and government; (4) morals. I am passing by two additional areas where the social implications undoubtedly exist, but where they as yet lie hidden—the impact of atomic knowledge on further scientific discovery and the use of atomic knowledge in medicine.

INTERNATIONAL RELATIONS

The advance of science and technology—the atomic bomb is merely one episode in that advance—poses an old choice with a new and terrifying urgency. Modern society shall avoid war or war shall annihilate modern society. Atomic energy may enable man to destroy himself. The great hope is that man will perceive his danger and act while he still has the power to guard against catastrophe.

There is no way to guarantee peace. Even if a successful attempt were made to win world unification by conquest, such a world would not be peaceful, democratic, nor free. I see no hope of world government by formula. We have to work from where we are, not from where we wish we were. The slow building and strengthening of a world community that will settle its disputes without resort to war is a process that cannot be achieved by a simple tour de force. It requires the efforts of scholars and scientists, of experts and administrators, of statesmen and political leaders, of teachers, both popular and academic, each contributing in his appropriate way. But it is possible to go beyond such general assurance and, in international policy, to identify certain specific opportunities for emphasis which are of critical importance in efforts to build a constructive and durable peace.

SUPPORT OF UNO

The very imperfections of UNO reflect the limits of the intellectual and moral climate of the world today. However, it is the available world medium through which to foster the habits and vested interests and acquaintances that make for an expanding role of international collaboration. Working through UNO is the practical way to build towards a world political order that can forestall resort to the atomic bombs of war. It is also one of the media through which to rebuild the fabric of international economic relations which war has demolished twice in our time.

AN INTEGRATED AND CONSISTENT FOREIGN POLICY IN THIS COUNTRY AND THE ORGANIZATION TO IMPLEMENT IT

It is extremely difficult for a country, ninety per cent of whose minds and interests have been turned inward, to develop and maintain an effective foreign policy. This did not matter so long as our foreign policy consisted of high tariffs, unlimited immigration, the Monroe Doctrine, and the Open Door in China. But today it does matter, for the foreign policy of what we complacently call "the most powerful country of the world" vitally influences both the cause of world peace and our own national self-interest.

It is easy and natural and fashionable today to criticize the State Department. In the division of labor of our governmental organization the State Department has to be the leader of our team for peace, as the War and Navy Departments were the leaders of our team for war. The fact of this criticism, therefore, is a wholesome sign. But the task is the task of all of us. For example, competent work by scholars on international issues such as the integration of military and diplomatic policy, or in the field of foreign economic policy, may count towards the structure of international peace as surely as the work of any striped pants diplomat. There are two aspects of the work of

the State Department which warrant mention. I do not see how it can be an effective instrument in the great responsibility which we carry until it achieves a greater degree of organizational continuity at the operating level than it now possesses. Perhaps (there will be many others who will know better than I) this is the point at which to begin the institution of a permanent undersecretary with a permanent staff of civil servants which remains unchanged even when changes in administration occur. Unlike the Labor Department, the Commerce Department, and the Agriculture Department, the State Department has no powerful group behind it concerned with its performance and protection. Perhaps there needs to be a "citizens pressure group" that will criticize, defend, and, nourish the State Department as an arm of government.

I have heard it said again and again in the last twenty-five years that this country brought able men to international conferences; that competent technicians had produced excellent specific memoranda; but that the overall determination of policy was inadequate and often hastily improvised. If this criticism be true, it may reflect the size of this country, its intellectual immaturity on international issues, and a preference to finesse rather than face and choose policies. But all our preparatory education and intellectual work can be nullified if we do not take thoughtfully and competently this final organizational step of policy determination.

RELATIONS WITH RUSSIA

If world war is to come again in the next twenty-five years, it is more likely to come between Russia and her allies and the United States and her allies than between any other combination of powers. And such a tragic and futile war would prepare the world only for complete social and political bankruptcy.

I have no advice to offer to diplomats in the difficult issues which they face; but I do have a suggestion for scholars and scientists. Russia has suggested, in her Academy of Science celebration, that science and scholarship may offer a foundation upon which the Soviet world and the Western world may meet. No one can say whether the channels of free inquiry in Russia will be open to objective Western students or not. But, if they are, it would seem wise from the point of view both of knowledge and of the cause of peace to encourage academic and personal contacts between the competent scholars and scientists of both countries.

INTERNATIONAL INSPECTION

I seem to have wandered far from the subject of atomic bombs; but atomic bombs dictate the elimination of wars, and the pursuit of that objective reaches widely into general as well as technical issues. I return now to a problem which seems nearer to the subject of this conference—international inspection as a means of controlling the use of atomic bombs.

I have been impressed with the complete faith expressed by some in international inspection as a means of controlling the manufacture and use of atomic bombs; then in turn by the complete lack of faith of others in its effectiveness and practicability. I do not know the answer, but this dilemma would seem to offer to natural scientists, engineers, industrial economists, and political students their opportunity to spell out the technical, political, and industrial issues involved in a system of inspection. Without the basis of such an analysis, policy cannot be wisely considered.

COMMERCIAL ATOMIC POWER

Since it is possible, by human intervention, to slow down the rate of atomic fission, I assume it to be only a matter of time before atomic power will be available at costs that make it commercially practicable. To go much beyond this statement on the basis of present information would be mere speculation. I view with some reserve the more enthusiastic predictions that the load of labor is to be lifted from the backs of men and that plenty will be enjoyed by all. The evidence for this optimism is not yet adequate.

Why speculate ahead of the evidence? Instead I call attention to the opportunity open for a collaborative study by physicists, engineers, industrial economists, and public administrators. The object of this study would not be to guess about the social adjustments which commercial atomic power might produce, but to follow closely scientific and engineering developments and describe, as the facts permit, the social issues and adjustments which are likely to ensue. Usually the interpretation of such change comes after the event. There is here an opportunity for natural scientists and social scientists, within certain limits, to predict social change and thereby to facilitate intelligent adjustment to it.

POLITICS AND GOVERNMENT

The current tendency in discussions of social effects of atomic energy is to emphasize the dangers of war and the possibilities of commercial power. The political and moral implications of atomic power are usually ignored. But in the future these implications may be found to be at least as important.

On the political side atomic energy looms as a giant new force propelling us towards the organization of society from the center. I give three examples: The May-Johnson Bill is one; and, although I share the concern which many scientists express over that bill, I suspect that any bill regulating atomic energy, which even the critics of the May-Johnson Bill might write, would contain many more restrictions on atomic physicists than have been traditional in scientific work. For the second example, consider the same centralizing tendency which would probably operate in the field of atomic power. When atomic power is developed for commercial purposes, it will not be developed by private utilities, or even by municipally owned or state owned systems. The power will be developed in Federal central stations, and the system will be a Federal system. Although existing channels of distributing the power may be used, the policies for production and distribution will be increasingly Federal policies. To the extent to which atomic power supplements other forms of power, the importance of central policies and central control will grow. The third example is in the field of political rights. If this country and Russia should go in for an armament race in atomic bombs, and the American people should come to realize that the Communist Party in this country is not only a political arm of the Soviet Union but could be a potentially important military arm, one wonders how long our traditional guarantees of political freedom would be maintained.

Such cases justify a query as to the impact, not only of atomic bombs and energy, but of all their born and unborn colleagues upon democratic political institutions. Moreover, what is the effect of such organizing of society from the center upon the status and independence of individuals; and, further upon the chances for peaceful international relations? How may the advantages of modern science and technology be reconciled with the conditions of effective political democracy and peaceful international relations?

The "Franklinian" minds capable of dealing with these questions, are not numerous but such minds can find issues worthy of their quality.

MORALS

Finally, I can only mention the moral implications of atomic energy. What is the effect on man of this possession of the ultimate power of the atom? It has been interesting to me to notice that, at the various conferences on atomic energy which I have attended, controls at the international level were discussed, and controls at the national level also; but the controls of a moral and educational nature within the individual were not mentioned even when representatives of theological seminaries were present. The individual, seemingly, had become too small change to matter. John Lindberg, of the Economic and Financial Section of the League of Nations at Princeton, has stated the matter well in an unpublished manuscript written before Hiroshima. He puts it that the "outer kingdom" has outgrown the "inner kingdom" and a "social unbalance" results which will not be redressed until a basic equilibrium is restored. He traces the competition in our society of the "earthly city" (society) based on power and the "beloved city" based on love and sacrifice. The tragedy of the atomic bomb lies basically in the fact that, to survive in a world of such powers, we are compelled towards even greater emphasis and preoccupation with the means and the instrumentalities and the psychology of power. (It is significant to me that thoughtful people in this country were more possessed by fear at the time of Hiroshima, when we were at the zenith of our power, than they were at Pearl Harbor when our defenses were down.)

There will be much declamation and exhortation about these social-moral implications of atomic energy and other scientific inventions. But, ahead of declamation and exhortation, we need honest clarification. The minds which can really help society to understand the moral implications of modern scientific developments may be those of natural scientists (who are so deeply concerned with the product of their labors), or humanists, or men of affairs, or social scientists. To contribute helpfully these minds need (1) to be really capable of "the general view," (2) to understand the realities of the social world and the history of social ideas.

In conclusion, I return to my figure of the iceberg. It may be that further knowledge about

atomic energy and further development of science and technology will point to problems of social adjustment quite different from those which I have stressed. But my guess is that, whatever the character of future scientific development, the main questions will continue to be questions of impact on war and peace, on power, on politics, and on morals. Whatever the course of developments, atomic bombs have made clear that the present is a time for greatness—a time for the abatement of pettiness of spirit—and a time for the pooling of disciplines.

I conclude with a quip which some wag used: "Atomic energy is here to stay but are we?"

THE IMPLICATIONS OF THE ATOMIC BOMB FOR INTERNATIONAL RELATIONS

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(Read November 16, 1945, in the Symposium on Atomic Energy and its Implications)

In his Message to Congress of October 3, 1945, President Truman stated that: "In international relations as in domestic affairs, the release of atomic energy constitutes a new force too revolutionary to consider in the framework of old ideas." Beyond a few facts and a few surmises about the military effectiveness and the cost of atomic bombs, however, I unfortunately have no materials to work with except a framework of old ideas, some of them centuries old, with respect to the inherent character of international relations. I suspect that practically every non-scientist is in substantially the same predicament, except that many are unfamiliar even with the old ideas about the character of international relations.

I am fully aware that I cannot tell this audience anything about the nature of the atomic bomb as a military weapon which it does not know more fully and more accurately than I do. But I want to disclose the atomic-bomb premises upon which my argument is based so that if my information is incorrect in any vital respect you will be in a position to discount appropriately the argument I base upon it.

A single atomic bomb can reduce a city and its population to dust. A single airplane can carry the bomb. A single person can carry the explosive ingredients of the bomb, and it can be deposited at an appropriate spot and detonated at an appropriate time by pressing a button or setting a time-clock. The bomb has a minimum size, and in this size it is, and will remain, too expensive—or too scarce, whether expensive or not—to be used against minor targets. Its targets, therefore, must be primarily cities, and its military effectiveness must reside primarily in its capacity to destroy urban population and productive facilities. Under atomic bomb warfare, the soldier in the army would be safer than his wife and children in their urban home.

Secrecy as to the fundamental scientific principles underlying the atomic bomb is already nonexistent. Secrecy as to manufacturing know-how is probably already less than perfect and can at the most delay the manufacture of such bombs for other countries by only a few years. The atomic bomb is susceptible of further improvement. But, even if our superior supply of scientists, of industrial resources, and of industrial technique could be relied upon to keep us always ahead of other countries in the quality of the national brand of bombs, this would probably have little strategic significance. The atomic bomb, unlike battleships, artillery, airplanes, and soldiers, is not an effective weapon against its own kind. A superior bomb cannot neutralize the inferior bomb of an enemy. It does not much matter strategically how much more efficient the atomic bomb can become provided superiority in efficiency affects chiefly the fineness of the dust to which it reduces the city upon which it is dropped.

There are differences between countries in their military vulnerability to atomic-bomb attack. Since the bomb can have destructive effect which will justify its own cost only if directed against major targets, a country is more vulnerable: (*a*) the greater the proportion of its population which lives in large cities; (*b*) the greater the average size and density of these cities; (*c*) the greater the urbanization or other regional concentration of its major industries of military significance; (*d*) the smaller its total and per capita resources of capacity for production (and stockpiling); therefore, other things equal, the smaller the margin of expendable resources which needs to be consumed before the military and civilian economies are brought to their physical or psychological breaking-points.

There seems to be universal agreement that under atomic-bomb warfare there would be a new and tremendous advantage in being first to attack and that the atomic bomb therefore gives a greater advantage than ever to the aggressor. I nevertheless remain unconvinced. No country possessing atomic bombs will be foolish enough to concentrate either its bomb-production and bomb-throwing facilities or its bomb-stockpiles at a small number of spots vulnerable to atomic bomb or

other modes of attack. Let us suppose that a country has been subjected to a surprise attack by atomic bombs, and that all its large cities have been wiped out. If it has made the obvious preparations for such an eventuality, why can it not nevertheless retaliate within a few fours with as effective an atomic-bomb counter attack as if it had made the first move? What difference will it then make whether it was country A which had its cities destroyed at 9 A.M. and country B which had its cities destroyed at 12 A.M., or the other way round? It may be objected that the country first to attack can evacuate its cities beforehand so that when the counter attack comes it will lose only its cities, but not their inhabitants. But mass evacuation of a great city is a process which is both time-consuming and impossible to conceal. Such evacuation would to any country feeling itself at all in danger be an advance signal that an attack was in the offing. It may be argued that the existence of atomic bombs would make a surprise attack by paratroopers directed at the production facilities for atomic bombs and at the stockpiles good strategy, and that therefore, while there may be no particular advantage in a surprise attack *with* atomic bombs, there will be a great inducement for a surprise attack with other weapons *on* atomic-bomb facilities and stockpiles. But these facilities and stockpiles can readily be maintained at relatively inaccessible locations and can be strongly guarded.

There seems to be no prospect of an effective specific defense against the atomic bombs. In theory their military effectiveness can be somewhat reduced, however, by planned decentralization of industry and deurbanization of population. Carried on on only a modest scale, this would have negligible military significance unless it was directed primarily at setting up a miniature war-economy and military organization, insulated from the economy as a whole and always ready to act on short notice in pursuit of military objectives even when the economy as a whole was engulfed in a disaster situation. Carried on on a grand scale, it would be painfully expensive; there would always be the risk, moreover, that before mass-decentralization had been carried far some new development of lethal weapons would have made it waste effort. In any case, I leave it to you to judge whether the decentralization of New York, Philadelphia, Chicago, Detroit, San Francisco, can be regarded as physically, economically, politically, practicable. But our military planners, in deciding upon the location of new facilities of military significance, should of course give careful consideration to the bearing of the atomic bomb upon the logic of strategic location. This logic calls for as wide a dispersal of facilities, as complete an avoidance of metropolitan areas as possible and as little dependence as possible of military communications and transportation, military stockpiles, and military staff personnel on urban-centered facilities.

The atomic bomb does not, *per se*, render armies, navies, airfleet, artillery, and TNT obsolete. But speculation on the nature of military strategy in an atomic-bomb world, if at this stage it can be sensibly pursued at all, must proceed from alternative hypotheses as to the phase in war at which atomic bombs would be used.

Let us first assume that the atomic-bomb phase would come early in a war. Each side having laid waste the other's cities, the hostilities would continue with weapons of less lethal power until a decision or a stalemate was reached. The major changes that the discovery of the atomic bomb would then seem to call for in the technical character of future warfare would be: first, that atomic bombs would supersede other weapons for attack on large cities and their inhabitants, and, second, that the drain of economic and manpower resources caused by the destruction, disorganization, and demoralization brought about by the enemy's use of the atomic bombs would force a drastically reduced scale of use of other weapons. It seems to me, indeed, that a war which opened with atomic-bomb attacks on both sides could then proceed only on a supply-from-stockpiles basis for a limited period and thereafter only on a token warfare scale, with defense in both stages at an advantage and large-scale offense, for logistic reasons, next to impossible.

A much more plausible hypothesis is that in a war between two fairly-equally-matched states possessed of atomic bombs each side would refrain from using the bombs at the start; each side would decide that it had nothing to gain and a great deal to lose from reciprocal use of the bombs, and that unilateral use was not attainable. The bombs would then either never be used or would be used only when one of the countries, in the face of imminent defeat, falls back upon their use in a last desperate effort to escape a dictated peace. In such a war the first stages at least would be fought with all the standard apparatus of war.

A third hypothesis is deserving of consideration.

The universal recognition that if war does break out there can be no assurance that the atomic bombs will not be resorted to may make statesmen and people determined to avoid war even where in the absence of the atomic bomb they would regard it as the only possible procedure under the circumstances for resolving a dispute or a clash of interests.

The atomic bomb does not change the ancient rule that victory in war will go to the strong. The atomic bomb does, however, create a new pattern of distribution of military power in one sense. More accurately, it restores an ancient pattern which was destroyed by the development in the nineteenth century of massive weapons of war and of great mobility of armies and navies, and by the development in the twentieth century of the airplane. The small country will again be more than a cipher or a mere pawn in power-politics, provided it is big enough to produce atomic bombs. The small country will still not have prospects of successful defense against an aggressor great country, but even the strongest country will no longer have any reasonable prospects of a costless victory over even the smallest country with a stock of atomic bombs. Even complete victory over a small country will involve the probable loss on the part of the victor of its major cities and their population. Such relatively costless victories as those of Prussia over Denmark, Austria, France in the nineteenth century, and of Nazi Germany over Poland, France, Norway, Holland, Belgium, and Denmark in World War II, will no longer be possible—or at least safe for an aggressive-minded country to count upon.

The atomic bomb makes war a prospect horrible to contemplate. Moreover, even without the atomic bomb other new military weapons of unprecedented capacity to destroy life and property already perfected or soon to be perfected threaten us with horrors not much less awesome than those of Hiroshima and Nagasaki. Every person of sane mind and sound morals is anxious that mankind be protected against these horrors by whatever political means are available. The physical scientists, presumably because they are better aware than we laymen are of the death-dealing potentialities of these new weapons, and because they have had more time to consider what dread fate is in store for us if these potentialities should ever become actualities, have been particularly active in calling for action, and rightly so. I gather, however, that they, like many others, think there *must* be an effective remedy, that such a remedy is in fact known and available, and that it consists in the establishment of "World Government." I gather also that many of them think that all that stands in the way of adoption of this remedy is the stupidity of politicians and ordinary citizens, or their failure to understand how terrible the atomic bomb is or how impossible it is for any country to retain a monopoly of it. I fear that the problem is not so simple; that complacency and ignorance are not the only barriers to world government.

Norman Cousins, in an editorial in the *Saturday Review of Literature* of August 18, 1945, which has received wide distribution, gives us the following advice:

> There is no need to discuss the historical reasons pointing to and arguing for world government. There is no need to talk of the difficulties in the way of world government. There is need only to ask whether we can afford to do without it. All other considerations become either secondary or inconsequential.

I do not think we can afford to take this advice to disregard whatever experience has to teach us, to substitute hysteria for history. We are told that when some danger menaces the ostrich he buries his head in the sand. Here we are advised to meet the menace of the atomic bomb by hiding our heads in the clouds. Neither appeals to me as wise procedure.

In theory the world can be effectively organized for peace through universal pacifism, through universal monarchy, or through world government, world government in this connection meaning a world state which in military matters at least can give the law to national governments or peoples. We do not know how to get universal pacifism. We do not want universal monarchy, or the rule of the world by a single nation-state; even if we did want it—presumably, for ourselves—we probably would not be willing to pay the price at which it would be obtainable, if at all. World government has been possible in the fairly recent past. It may again be possible in the somewhat distant future if, as a result of the wide distribution of atom bombs, or of other conceivable developments, military power is once more widely distributed. But I do not believe it is possible now or even that it is possible now definitely to begin planning it for the future.

The successful establishment of the United States of America out of separate colonies is often

cited in support of the practicability of a United States of the World. The American precedent has little bearing on the present problem as long as the United States and Soviet Russia have a near monoply between them of military power. Let us suppose that the New York and the Pennsylvania of 1789 were of approximately equal importance, that one of them at least was at some distance from the center of government, and that between them they had, say, 80 or 90 per cent of the total military resources of the Union. Under these circumstances, neither of them could have been relied upon, at times of crisis and of strong emotions of fear or anger, to have accepted without resistance a ruling from the central government which seemed to it to threaten its vital interests, nor could the ability of the central government to overcome that resistance by force or otherwise have been relied upon. That is substantially the situation we are in now. The United States and Soviet Russia are each too strong, relative to the total power potential of the world, to be proper members of a world government, even if their governments and their peoples were genuinely willing to enter such a government. In a narrow legal sense sovereignty can easily be formally surrendered, but actual power is more difficult to surrender and can be effectively surrendered only to an agency still more powerful. In the present state of the world such an agency with superior power not only does not exist but cannot be manufactured out of existing ingredients, even if the genuine will to do so existed, *unless that will goes to the extent of preparedness on the part of the United States and of Soviet Russia to dismember themselves.* Splitting the United States and splitting Soviet Russia seem to present a more difficult problem than splitting the atom proved to be. Setting up a facade of world government where the power-basis for its successful functioning was not present would be worse than useless. No government would be fooled thereby into a false sense of security, but every government would be impelled to pretend that it was, and all diplomacy would be carried out in an atmosphere of superficially-concealed insincerity.

I am forced to the conclusion that the only conceivable ways in which the world even in theory could be effectively organized so as to assure peace are not available now. We may regret this or we may rejoice in it. I for one deeply regret it. But our regret and our joy are equally irrelevant. That does not mean, however, that there is nothing that can be and should be done to make war less probable. On the contrary. Let us consider the possibilities of action in this direction.

The balance-of-power system is discredited today. References to it, even by professional historians and international lawyers, commonly imply either that it was a system for preventing war which repeatedly failed or that it was a system for making war which often succeeded in its purpose. The balance-of-power system had, in fact, neither peace nor war as its primary objective. Its primary objective was the maintenance of the independence of the states in the system by associating states in alliances too strong to be overwhelmed by any single state or combination of states outside such alliance. The principle of the balance-of-power called for defensive wars and even for preventive wars to stop any power from growing so strong that it could upset the balance. The system often was abused. During the period of its dominance as a European system, say, 1648 to 1918, its record in preventing war was certainly not striking. Indeed, it probably was itself responsible for starting more wars than it prevented. As human institutions go, however, it did have extraordinary success in attaining its primary objective, that of maintaining national independence. To the best of my knowledge, only one major European state, Poland, and only a few minor German states permanently lost their independence through external aggression in the entire period 1648 to 1918, and in even these instances the failure of England to play its customary and, I am willing to avow, its useful role in the balance-of-power system was probably a significant contributory factor. The balance-of-power system also deserves some of the credit for the receptiveness of belligerents during that period, including definitely aggressor nations, to limited warfare when actual hostilities were under way, to early termination of hostilities, and to moderate peace terms.

Whether we like or detest its record, however, the balance-of-power system is probably now only of historical interest. In the first place, the same factors which have created new barriers to world government have probably destroyed the availability of the balance-of-power system. To have any chance of effective operation in maintaining international equilibrium, the system requires that military power be fairly widely distributed so that there are no overwhelmingly strong concentra-

tions of power, even regional ones, in single states, and so that there is always some hope, or fear, that timely negotiations of new alliances will restore a balance temporarily destroyed. Abstracting from the atomic bomb, the world was emerging from World War II as a two-power world, with Britain deprived of the necessary economic base for sustained military effort, with Germany, Japan, and Italy reduced to military ciphers, and with France's underlying weakness finally exposed to view.

The development of the atomic bomb promises to restore some military significance to the weaker countries; it gives a strong weapon to *any* country able to use it. It thus tends to make all countries strong, or to make all countries weak, as you prefer. It seems doubtful, however, whether it goes, or will go, far enough in that direction, whether it will scatter military power widely enough to make it possible to create a single world agency strong enough to exact obedience from any single country. Should it do so, however, then not only an effective balance-of-power system but even world government will again be possible, and to the discovery of the atomic bomb will belong the credit. On the other hand, the atomic bomb removes the physical and administrative restrictions on warfare which helped to make "limited-warfare" attractive even to aggressors and therefore tends to deprive the balance-of-power system of its only merit with respect to the issue of peace or war, namely, that it reduces the damage done by war when war does occur.

This leaves a Concert or League of Great Powers, committed by solemn covenant to the maintenance of peace, as the only immediately available type of political institution for preserving peace. The League of Nations, as it actually operated, was, I believe, essentially a Concert of Great Powers. The United Nations Charter, with its single-veto privilege for the Great Powers, provides more frankly and honestly for such a Concert. The essence of Concerts of Powers is that they aim to include all the major powers; that they start with good intentions; that they have the means and have agreed or can agree upon the procedures by which to enforce peace upon the small and weak countries; but that they have neither the means nor the serious intention to enforce peace upon each other. They should not be despised as useless or evil. Earlier Concerts of Powers did serve to maintain peace for a time. The League of Nations never had adequate membership and never was given a fair chance. The United Nations Organization will start with at least two advantages over the League of Nations: essentially complete membership and an ambitious program of beneficent economic and social activities which may succeed in fostering a feeling of community between the governments and the peoples of the world strong enough to withstand the strains of the clashes of interest and of emotions which will inevitably arise. But Concerts of Powers are essentially self-denying ordinances, embodiments of good resolutions terminable at will and unilaterally. They cannot have within themselves effective means for *enforcing* their own survival. They may promote peace; they cannot assure it. As an English poet, Blackmore, said in 1700 of an older Concert of Powers:

> To Leagues of Peace the neighbours did agree
> And to maintain them, God was guarantee. . . .

There is one more thing, in my opinion by far the most important, that can be done although it is unfortunately not in the least spectacular, revolutionary, soul-stirring, or exciting. That is the conscientious and unrelenting practice by the statesmen of the Great Powers, day after day, year after year, of mutually conciliatory diplomacy. Wilful disturbers of the peace do arise from time to time: Louis XIV, Frederick the Great, Napoleon, Bismarck, Hitler. But for the most part wars arise out of mutual fear of peace, out of fear of loss of national independence or of other nationally treasured objectives unless war is resorted to, more than out of love of war or than out of lust for war booty. Countries most often go to war because they fear the consequences of remaining at peace. If rulers act as statesmen, and if their peoples permit—and still better, demand—that they so act, if rulers so behave as not to arouse or sustain fear in other countries, lasting peace will still not be guaranteed, but it will be probable. By making the peace a mutually more satisfactory one, we will further lessen the risk that some day some country may fear continuance of the peace more than it fears war. By adding to the horror of war and therefore to the attractiveness of peace, the discovery of the atomic bomb will aid instead of hinder the diplomacy of peace. In any case, it is on the quality of postwar diplomacy and of postwar diplomats, and on the texts of charters only as they are incidental to, facilitate, and are supported by the exercise of

good diplomacy, that we must rest our main hopes for the maintenance of peace.

It would be wonderful if it were possible to *enforce* peace. It would be wonderful if a workable scheme could be devised whereby the atomic bomb itself could either be used as the equivalent for the world of the policeman's baton or could make the baton unnecessary. For the reasons given, however, I believe that this is under existing circumstances not within the realm of the possible and that at the best it can be regarded only as a distant goal. And if it is not, or even probably not, possible in the near future, I believe it is unwise to pretend that it is possible, and thus to divert attention from those things that *are* possible and that are possible *now:* full support of the United Nations Organization so that it may realize its fullest potentialities for promoting mutual trust and collaboration in good causes; public insistence that diplomats gather with the determination to reach agreement on vital issues rather than with irresponsible readiness to quarrel on secondary issues. In both cases, this means a call to action, immediately, and right here in our own country as well as elsewhere.

THE CONTROL OF ATOMIC ENERGY UNDER THE CHARTER

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(Read November 16, 1945, in the Symposium on Atomic Energy and its Implications)

I MUST ask your sympathy this afternoon because I had a paper all prepared in which I was anticipating what might be done by the Government. Part of it has gone into the wastebasket because the Government has already taken action and issued the joint Communiqué on the Three Power Conference. I salvaged a few pages of the introduction, however, and the concluding sections.

It is commonplace in the discussion of atomic energy to point out that its uses are twofold. On the one hand, the destructive capacity of the atomic bomb and, on the other, the as yet unrealized, but nonetheless real, possibilities of use for constructive purposes in industry and economics generally.

There is, however, a third field which as yet has not been defined and of which this meeting furnishes a good example. It is the re-making of the sciences themselves. For the major readjustment involved in the control of power calls for a coordination of the work of those whose field is the study of power with that of those whose field is the study of control.

Both the physical and political sciences are already aware of the need of this coordination, although both of them are still fumbling as to the method to be employed. In the very first official document describing the conquest of atomic energy as ultimately locked in the bomb, the Report to the War Department by Professor Henry D. Smyth, the point is clearly made in the closing paragraphs that the achievement of the scientists stopped short with the problem of human conduct, and that that problem belonged to the political and social sciences.

It would, however, be a misunderstanding of the implication of this remark if it were taken to mean that the social and political sciences had already in hand the solution of their problem of control. Neither history nor political science has precedents to offer which are adequate to deal with this new and all-embracing problem. They have, it is true, a knowledge of the fundamental principles of economics and public law, based upon a careful analysis of history. But this is as far from the knowledge of the actual working of human conduct as research in the fundamentals of the physical sciences is removed from the actual working of organized industrial processes, by which the bomb was put together.

The link between the study of the fundamental principles and their application is popularly known as "the secret" in the case of atomic energy. The term was ill-advised, not because it was ambiguous, but because the word is too seductive, too good a headline, too suggestive. Moreover there is a similar secret in the field of the political sciences, for no one has as yet been able to offer a complete and adequate answer to the question, what kind of political organization can oversee the control of atomic energy in a way which will render it safe, both for ourselves and the rest of the world and, at the same time, open up its constructive possibilities. The communiqué of yesterday underlies this fact.

The limitations of the political sciences are only too well known to those who work in them. It would be strange if this were not the case, for they are continually reminded of it by the politicians, the journalists, and the world generally. They were therefore not surprised when certain members of what I might call the mathematical sciences ventured in these last months boldly to enter their field and, if need be, take it over by proposals for world government and other such things which, from the standpoint of the emergency of today, seemed called for.

Unfortunately, the technique of the physical sciences is quite different from that of the political sciences which do not have mathematics as their base. In the study of human conduct a major element is what is known as the "imponderable." The very word itself indicates that it escapes the analysis of weight and exact measurement. This is as fundamental a fact in the study of human conduct as energy in the physical world.

No Einstein equation can measure political action against the mass of inherent tendencies in habits of thought and ways of living. The measurements of public opinion which are so largely in vogue today do not, in my opinion, furnish any

sure guide to the attitude of citizens toward unforeseen circumstances which do not fall within the normal pattern of life. In short, political and economic conduct has to be studied in its own setting. Some of its tendencies are as old as the Ice Age and some as new as yesterday's newspaper.

The first qualification of a political scientist is caution in generalizing beyond the scope of experience. This applies to both the policies of nations and to the structure of their relationship. The latter should be functional with reference to the former. Yet there is a tendency to violate this fundamental principle upon the part of those who see clearly the ultimate goal which they would reach, and yet are impatient of the steps by which they must proceed.

The best example of this is to be found in the demand for a world government to be erected by a revolutionary fiat in order to have a supreme authority for dealing with atomic energy. The phrase "revolutionary fiat" would perhaps be shocking to some of those who subscribe to this short-cut to a millennium, but from the standpoint of history and political experience it is nothing less.

Let us pause for a moment to see what it would amount to if carried out in absolute terms at the present time. We had just completed the Charter of the United Nations and secured the consent of the Senate to its ratification by an unparalleled majority when, only a few days later, came the news of the atomic bomb. To scrap the Charter and start over again would be about the most irresponsible act which any nation has indulged in.

It is hard for us to realize the effect upon our standing in international politics from the fact that, after having more or less forced the League of Nations upon a somewhat reluctant or doubting world in 1918, we drew back from it in 1920. When, at the close of the Second World War, we proposed a new League of Nations, under another name, the first question which came to the minds of other Governments and peoples was whether we would follow a similar course this time and pull out from the institution which we had erected upon meeting the first real difficulties with which it would have to come to grips. The mere proposal that we should do this, even when not linked in any way with official comment or action, lessened our influence for carrying through the real obligations of the Charter.

Moreover, the only way to substitute a constitution of world government for the Charter of the United Nations would be by the calling of a conference similar to that in San Francisco, under a pressing demand for immediate action. Anyone who has had experience with international conferences knows that they never can succeed, except by a special dispensation of Divine Providence, unless they are adequately prepared beforehand; and adequate preparation means long preparation. The preparation for the San Francisco Charter preceded that of Dumbarton Oaks by a year and a half, during which a small committee of consultants, of which I was a member, worked in the State Department under the chairmanship of Undersecretary Sumner Wells. From the spring of 1942 to the spring of 1945 is a long period of preparation, but without such careful preparatory work it is very doubtful if the San Francisco Charter could have been agreed upon by the representatives of so many nations.

We not only have the lesson to be drawn from the successful use of preparatory work at San Francisco but we have as well the warning of unsuccessful conferences due to inadequate preparation in at least three well-known instances: the Genoa Conference of 1921, more or less improvised by Lloyd George; the Economic Conference of 1933, more or less improvised by President Roosevelt; and the recent Conference of Ambassadors, which hardly seems even to have been improvised. To remake the constitution of the world and place within it an absolute authority for the prevention of war and its greatest weapon, the atomic bomb, involves so many unsolved questions that those who propose settling it all by a single formula are really but adding confusion to our thinking.

So far I have been quoting from the text of my prepared paper. Instead of continuing with it, I shall pause to comment on the communiqué of the Washington meeting, published this morning.

First of all let me say that everyone ought to be thankful that we have at least a working document which should help us to escape from the confusion which has prevailed in recent weeks concerning this vital problem. While the communiqué is still not wholly adequate, I cannot conceive that anyone would readily take a negative attitude toward the effort to clarify the situation. Anything, therefore, that I may say in critical comment of the text must be read in connection with this initial statement of appreciation that there has been a communiqué and that at last we are face to face with definite policies.

The first part of the communiqué contains nothing that is really new. Sections 1 to 6 do not depend upon or definitely connect with the Charter of the United Nations. They deal with a program of bi-lateral agreements between sovereign states which, if carried out effectively, provide a basis for the action to be taken under the Charter.

Sections 1 to 3 might be called the preamble to the communiqué for they contain a statement of basic principles. This is especially true of section 3 which states that "no system of safeguards that can be devised will of itself provide effective guarantee against the production of atomic weapons by a nation bent upon aggression." The text which follows deals with these very safeguards. At first sight, therefore, there is an apparent contradiction between this negative statement and those which follow. It is unusual, to say the least, to have a legal provision against crime begin with a disclaimer stating that crime will probably continue in spite of the law. Possibly this sentence was inserted in the communiqué in order to reassure those who might be fearful lest the old safeguards against war—army, navy, and air force —be neglected in the assertion of a rule of law. If that was the purpose of this sentence, I think we should all agree with it, for we are certainly not ready for any such revolutionary change in our political structure as the elimination of the armed forces of the nation as a measure of protection against aggression.

A closer reading of the text, however, shows that the paradox is only apparent and not real, for the sentence merely states that no institution will work "of itself," unless adequately supported by the national will. That is a commonplace upon which there would be universal agreement.

Articles 4 and 5 deal with freedom for scientific research and the international exchange of scientific knowledge. It is surely not necessary for me to pause even for a moment over these basic points in the establishment of reciprocal confidence among nations.

Article 6 brings us up against the central problem, the sharing of the "secret" in the production of atomic energy. This should not take place until there are "effective, enforceable safeguards" against the use of atomic energy for destructive purposes. Had the document stopped at this point we should have been left only with general principles and a relatively negative conclusion. Fortunately, however, this long introductory section is followed by practical proposals upon which we should concentrate our attention.

Article 7 calls for the erection "at the earliest practicable date" of a commission, set up under the United Nations Organization, to prepare recommendations for submission to the Organization. Then the text goes on to indicate the scope and method of that commission. It must extend, not merely exchange, information, keeping in mind the essential purpose of the Organization, which is to maintain peace.

The proposals which the commission is to frame for the United Nations reach bedrock in the two last items of Article 7. It is to plan "the elimination from national armaments of atomic weapons and of all other major weapons adaptable to mass destruction"; and to provide "effective safeguards by way of inspection and other means to protect the complying States against the hazards of violence and evasion." Surely, here we have a program which should satisfy those who are calling for a super-state, in the eager hope of immediate measures of safety.

It is in line with those major objectives that Article 8 proposes that the commission "proceed by separate stages, the successful completion of each one of which will develop the necessary confidence of the world before the next stage is undertaken." This is political wisdom and practical common sense. There are some who will be disappointed because the program does not attempt to cover the whole ground at once. But mere mechanism will not achieve the final purpose even if it could be agreed upon by governments. We must have the support of enlightened public opinion; otherwise the international instrument will not work. Such meetings as this are important contributions to the action of government, for they help to clarify our thinking on the fundamentals of the problem.

It would have been a major blunder to have attempted to outline in detail at the present time just how the control of atomic energy could be achieved. Instead of rushing to conclusions with inadequate data, the problem is left with the UNO where an adequate and competent commission is to be appointed to study this most difficult problem that the nations have ever faced. It is no exaggeration to say that the political problems are even more difficult than those which the physical scientists have solved. The nucleus of the human mind is protected by a shield of electrons

more potent than those of uranium, and it is harder to crack than any physical element.

So much on the communiqué. Now let us turn to the Charter itself and see how it can be used by adjustment, implementation, or revision, for all three may be involved before it measures up to the final test in the control of atomic energy.

The most definite proposal for amendment which has yet been made is that by Captain Stassen, one of the delegates who framed the Charter, when, in a recent address before the Academy of Political Science, he suggested a revision of Article 43 which has to do with armaments and their control. Undoubtedly that section has been rendered antiquated already by the atomic bomb. It proposes international policing by contingents from the member States very similar to the method outlined in the Covenant of the League of Nations. There is provision for free passage of troops to the scene of disturbance, and the armed forces are to be planned and presumably directed by the Military Staff Committee of the UNO, composed of the chiefs of staff of the great Powers. Captain Stassen proposes that, in place of this resort to the time-worn methods of the past, the Security Council should be made the guardian of the few atomic bombs which might be necessary for police action against an aggressor, and that all national armament in bombs be forbidden.

Obviously, the first step in putting this plan into operation would be an agreement on international inspection so as to make sure that no nation prepare secretly weapons of atomic energy. The question would then arise whether this inspection should be in the hands of the Security Council, which is a political body, or of the Staff Committee, which is military. I regret that I am not able within the limits of this paper to deal at greater length with Captain Stassen's admirable presentation of the first definite attempt to deal with the mechanism of security of the UNO under the conditions of atomic energy. Before leaving it, however, I would like to answer one of its critics who has charged Captain Stassen with having put undue emphasis upon military control in the prevention of war. No one who knows his contribution to the making of the Charter could for a moment suppose that he was unmindful of the fundamental fact that the military arm of the UNO must submit to political control or it becomes a menace to peace rather than a safeguard of it. Captain Stassen's plan is not a substitution of militarism for politics; it is merely a detailed suggestion for bringing the military technique within the field of practical discussion.

There are, however, other points to keep in mind in the adjustment of the Charter to the atomic age. Fortunately, the Assembly was, in the last days of the Conference, given wide powers of oversight in all matters within the scope of the Charter. It is specifically stated in Article 11 that it "may consider the general principles of cooperation in the maintenance of international peace and security, including the principles governing disarmament and the regulation of armaments." This clause did not mean very much in the eyes of those realists who thought, as realists generally think, of the pattern of the world as having been already established, so that all one needs to do is to fit oneself into the pattern in order to achieve harmony, nationally or internationally. The explosion of the atomic bomb, however, reached suddenly into this area of general principles of armament. While the Security Council is upon the whole limited to dealing with crises, the Assembly is the body which is more properly fitted to deal with the fundamental issues raised by the discovery of atomic energy.

Now in Article 22 the Assembly is authorized to "establish such subsidiary organs as it deems necessary for the performance of its functions." It surely is beyond argument that the one subsidiary organ most needed is a UNO Commission on Atomic Energy. There is similar authority in Article 29 for the Security Council to create whatever agencies it needs. Surely common sense would indicate that the two bodies could be served by a single Commission on Atomic Energy. Such a Commission should be advisory, and something more. Composed, as it would necessarily be, of a majority of scientists, along with a limited number of experienced men of affairs and statesmen, it would in the very nature of the case be the one body of the UNO which would be capable of carrying out or supervising inspection in laboratories or scientific plants. If we keep in mind the fact, so definitely emphasized by Molotoff in his recent address, that the nations of the world need atomic energy primarily for constructive peacetime purposes, the Commission on Atomic Energy of the UNO would have an almost unlimited scope in which it could bring mature and weighted judgment to the policies of governments and help, more than any other organization could, to build up the world community in which war will some day become an anachronism.

Here is the heart of the problem. Very wisely there is no effort to solve it off-hand by any general formula. Instead, the United Nations is to place it in the hands of a competent body charged with a task without precedent in history, that of dealing not only with the instruments of war but with war itself. The rule of law is to be established under a regime of lasting peace. But what is the rule of law for the atomic age? Certainly not international law as it stands at present, but a new rule of law which must be worked out by the United Nations somewhat as the common law of England was worked out when royalty took over the task of fitting into a single mold the folkways that had stood the test in the common, daily, dealings of man to man. Such a concept of law is not static nor codified, but capable of adaptation to changing circumstances while holding strongly to fundamental principles. This is not the kind of thing which has been advocated in widely circulated books recently, to which some scientists have given their assent. The law of nations will have to be worked out by bodies representative of the peoples of the world who bring their varied experience of the past and problems of the present and future to the test of application in the world community. Its basis must be peace, not war. There will have to be safeguards of freedom against even the authority of the United Nations Organization, as well as safeguards in support of its authority.

I suggest that the way to make progress in this difficult political problem is to analyze the Charter of the United Nations and the official statements like this communiqué of the three Governments issued today, and that that analysis should be carried out with the same objectivity as the analysis of uranium; for there is a political science which is capable of adaptation to the problems of the present and the future.

Let us turn hurriedly now to the Charter and see how it might work. It covers three great areas of human interest, security, welfare, and justice. Since the bursting of the atomic bomb all attention has been centered upon the problem of security, and it is with that which we shall have to deal today. But we must not forget that economic and social welfare and the development of international justice are the real constructive elements for which security provides the possibility of permanence. You cannot build a society on police power alone. That has never been done except in terms of tyranny.

It has been charged that the veto of the Great Powers in the Security Council is a device which tends to falsify the United Nations in this regard, but we cannot forget that the Assembly, representing the whole community of nations, has the possibility of checking this development to a greater degree than has been popularly appreciated. In the San Francisco Conference very wide terms of reference were inserted in the Charter, chiefly by the insistence of the Australian representative, Mr. Evatt, and other representatives of the smaller nations. People have not paid much attention to the possibilities of limitation of the veto of the Security Council. Take a sentence like this: "The General Assembly may discuss any question or any matters within the scope of the present Charter" (Article 10). This was a happy formula, for it is difficult to deny the Assembly the right to discuss anything, since discussion is a common right of people everywhere. But then, in Article 11, the Charter built on this general provision of Article 10, and went on to say that "The General Assembly may discuss any questions relating to the maintenance of international peace and security brought before it by any member of the United Nations or by the Security Council or by a state which is not a member of the United Nations" and may make recommendations not only to the Security Council but also to the states concerned. There is an exception in the case of an emergency; but these two clauses, Articles 10 and 11, are in my opinion pertinent for the handling of atomic energy under the Charter.

The Security Council is framed and designed to deal with acts in time of crisis. The Articles with reference to the Assembly deal with general principles. Perhaps this is one of the reasons why they were accepted at San Francisco, for there are those who think that general principles do not matter, and that the pattern of the past supplies enough guidance for the future. Suddenly, however, we find that the general principles of disarmament and cooperation for peace are brought subject to a far-reaching challenge by the atomic bomb. Some day small powers may be great powers if they have atomic bombs at their disposal. Now this problem lies in the hands of the Assembly, in my opinion, although it is also in the hands of the Council if it is an emergency question. It at least would be just common sense to use the Charter in this way.

Now turn to Articles *22* and *29*. These little

articles did not seem important at first sight, but are vital now. According to Article 22, "The Assembly may establish such subsidiary organs as it deems necessary for the performance of its functions." Article 29 empowers the Council to do the same. We can stop right here because evidently the Charter provides for dealing with something never dreamed of in San Francisco, something threatening the peace of the world at present, and definitely modifying human relationships for all time. Therefore, under either Article 22 or 29, or both, subsidiary bodies are available to deal with atomic energy.

Here is where I would criticize the Washington communiqué of today. It does not link up with these Articles of the Charter as closely as I think should have been done. However, that can be taken up by the Preliminary Conference in London now, or in the meeting of the Assembly in January, and then in the Council which will be established.

There are some, however, who are skeptical about leaving a matter of this kind to a Commission. It would be a calamity if when the Commission is appointed it should lack adequate support in an informed public opinion. That is one of the reasons why a meeting of this kind is so important.

Now, let me turn for a moment to the major question which lies back of all of this, the elimination of war itself. Throughout all the ages there have been protests against war by prophets and teachers in all of the great religions and philosophies. There never was, however, a clear definition of war itself, distinguishing between wars of defense, which were legitimate, and wars of aggression, which were not. Generally, therefore, nations fighting wars claimed that they were fighting in their own defense. International law, from the seventeenth century down, never grappled with this fundamental problem effectively, but limited itself to lessening the horrors of war. The theory of international law was that war might ultimately be lessened down to a vanishing point. The First World War, however, definitely and forever ended that line of the development of international law because war became total war from then on.

The first to see this were the Germans. The British followed a year and a half later, and then we fought it on the same terms—total war. This Second World War began from the first along the principles established in the First World War. Therefore international law has to be remade to fit the situation which has now developed. I do not mean to say that there is not a great deal to go upon in the international law of the past, or that it will not furnish solid foundations upon which to build. But we need to face the future with clear and open minds with reference to this completely changed situation.

Total war is not capable of use in the way in which war was formerly used, as an instrument of national policy, because the nations using it for policy find their aim distorted. They are destroyed along with their victims, so that in the field of total war, of which atomic war is the supreme example, we have reached a situation in which we must get rid of war itself since it is no longer an instrument of policy but an instrument of universal destruction.

Now then, how are we going to do that? I suggest that the first thing needed is to find out whether there is a threat of war in any country which makes it necessary for us to be on our guard. This calls for inspection. But that field is not easy to enter because some of our great industries would object to such an inspection. Yet, unless there is inspection, there is no way to eliminate international suspicion, which is a basis of war.

This is the kind of problem which the American public will have to confront in the coming months. We should not be scared of it. If we really mean that we are passing from the old barbarous world in which the claw was still dripping with blood as in the old jungles, if we are really passing from that to an era such as has been sketched for us here today in which the moral law may be established, then we must play our part as a nation in using our sovereignty to build a community of nations which can gain and maintain the confidence of all men of good will.

WORLD CONTROL OF ATOMIC ENERGY

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(Read November 16, 1945, in the Symposium on Atomic Energy and its Implications)

ALL scientists seem to agree on the necessity for effective world control of atomic energy. There is now much to justify hope and belief that such control will be attained although the road to it may be long and difficult.

The declaration issued jointly by President Truman and Prime Ministers Attlee and Mackenzie King on November 15 marks the first major step in a constructive program for the solution of the problem of the effective world control of atomic bombs. It is proposed to accomplish this by consolidating and extending the authority of the United Nations Organization so as to establish "a rule of law among nations and to banish the scourge of war from the earth." This goal of world government is to be attained "in separate stages, the successful completion of each one of which will develop the necessary confidence of the world before the next stage is undertaken."

A Commission is to be set up under the UNO to promote a wide exchange of scientists and scientific information and to submit recommendations for the control of atomic energy to the extent necessary to ensure its use only for peaceful purposes, for elimination of atomic weapons from national armaments, and for effective safeguards by way of inspection and other means. It is hoped to create "an atmosphere of reciprocal confidence in which political agreement and co-operation will flourish."

The proposed solution of the problem of the atomic bomb involves essentially a voluntary limitation of sovereignty of powerful nations to the degree necessary to form a world government capable of preventing war. The difficulties are great but the penalty for failure is world disaster.

We have already started an armament race; we are continuing to make bombs and the materials for them. Churchill has stated, "It is agreed that Britain should make atomic bombs with the least possible delay and keep them in suitable safe storage." Molotov, in his report of November 6, said, "We shall have atomic energy and many other things too."

It is unfortunate that a declaration like that of November 15 was not made by Britain, Canada, and the United States at the time that the atomic bombs were dropped in August. To have done so might have prevented or delayed the starting of the armament race. We may hope, however, that the steps that are now planned may lead to a stopping or slowing of the race before it is too late.

In discussing a program for possible attainment of effective world control of atomic energy we must be aware of the difficulties to be overcome and form an estimate of the time available for reaching the goal. Many of these general questions are being dealt with in other papers presented at this meeting. I wish to consider particularly the stages that are likely to arise during an armament race and the degree to which these will bring insecurity. This must involve a frank discussion of the characteristics and capabilities of particular nations.

FOUR STAGES OF AN ATOMIC ARMAMENT RACE

In the first stage which now exists we alone have atomic bombs and gradually acquire a stock pile. During this stage we are secure but other nations may feel insecurity to the extent that they are not sure of our intentions.

During the second stage one or more other nations will be making atomic bombs but will not yet have accumulated stock piles sufficient to destroy all of our major cities whereas we will presumably have enough to destroy theirs. Any atomic bomb attack on us would be followed by devasting retaliation; so we still feel moderately secure but other nations are very insecure.

The third stage will arrive when several nations have stock piles of bombs and means for delivering them sufficient to destroy all major enemy cities. Any attack will almost surely be followed by retaliation and will lead to world war. All nations will then be very insecure.

If the race continues long enough, a time will come when one nation, perhaps not the United States, discovers how to make bombs so powerful or so cheaply that it becomes possible not only to

destroy the cities of the enemy, but to cover practically the whole country and to kill so much of the population and destroy so many of the bomb launching sites that there can be no effective retaliation. During such a fourth stage the insecurity will become intolerable. A nation which believes itself able to strike without suffering from retaliation and fears that some other nation will soon reach that stage may feel itself justified in launching an attack to prevent future annihilation. A war started under such circumstances is not likely to be a draw. The victor will then have to do what Hitler tried but failed to do—exercise absolute world control—even if originally it had no desire for world conquest.

WHAT NATIONS CAN GET ATOMIC BOMBS AND WHEN?

There are fortunately no easy ways to make atomic bombs. Because of the nature of the chain reaction it is not possible to make bombs much smaller than those already used. The isotope separation needed to produce pure U-235 is extremely costly and must be carried on in very large plants to be economical. The piles used in making plutonium require many tons of materials of extreme purity and the recovery of the small amounts of plutonium that are produced is made difficult by the radioactivity of the products which necessitates remote control of complex chemical processes.

There is now no such thing as "the secret of the atomic bomb." Details of the construction of the bombs and of technical processes of manufacture are now being kept secret but this will not delay the building of atomic bombs by other nations by more than a year or so.

To produce bombs a nation needs a few scientists of high caliber with a large staff of scientifically trained men, well developed industries, skilled technicians, and an efficient organization. Such countries as Sweden and Switzerland might meet these requirements, but the populations are too small to support projects of the magnitude needed unless in the future far easier ways of making bombs are discovered.

A nation will be led to undertake such large projects only by sufficient motivation and incentives. These involve primarily questions of prestige and the intensity of the feeling of insecurity which may develop during an armament race. With small nations prestige and even insecurity are not likely to be sufficiently strong incentives to cause them to engage in large projects since these nations are already accustomed to seeing other nations outstrip them in military preparations.

The high cost of producing atomic bombs is not a serious obstacle for large nations, especially when we consider that these take the place of other weapons which would cost even more. The fact is that atomic bombs, in terms of the damage done, are the cheapest weapons ever devised. The cost of manufacture of a bomb, once the plant is in operation, has been given as roughly $1,000,000, and such a bomb destroys nearly everything within an area of about ten square miles. Over suitable targets the damage done vastly exceeds the cost of the bomb and its delivery. The ratio is at least ten times more favorable than for other types of bombing.

England is undoubtedly the nation, other than the United States, that can first produce atomic bombs. However, because of our understanding of the English people and our confidence in their motives, I doubt if English possession of these bombs will create any strong feeling of insecurity in America.

The next country to make bombs will probably be Russia. Because of the differences in the forms of government between the Soviet Union and the United States and the lack of mutual understanding that has long characterized our relationships, both nations are likely to feel insecurity during an atomic armament race.

Our cooperation with Russia during the war was limited in general to the field of operations. Many of the difficulties that will probably beset the development of effective world control of atomic energy might have been avoided if England and the United States at an early date had invited Russia to participate in the development of the atomic bomb.

A TRIP TO RUSSIA

I was one of sixteen Americans who were invited to attend the 220th anniversary of the founding of the Academy of Sciences of the USSR in Moscow and in Leningrad during June 1945. We had excellent opportunities to observe Russian scientists at work and to learn of the extensive science program that is being planned.

The attendance at the meetings, banquets, etc., held in commemoration of this anniversary was about eleven hundred, including about one hundred and twenty foreign scientists as guests. The fact that such an elaborate program was arranged

for a date only about a month after the ending of the war in Europe demonstrates that the Soviet Government considers fundamental science to be the foundation upon which they expect to develop their postwar economy. At these meetings it was emphasized that science has always been international in character and this cooperation has been of great benefit to the whole world. The hope was expressed that after the war such cooperation could be extended to other fields.

We visited many of the institutes of the Academy and everywhere found the greatest friendliness and found that all scientific matters could be discussed with complete freedom. We all hoped that the Russian scientists could pay us a return visit.

Much of the work done in the institutes during the war was of a long-range character that would find application only after the war. It had been possible to defer men from military service for such work—something that would have been impossible in the United States. The universities, of which there are now seven hundred ninety, were training more men than ever during the war, but the courses were reduced in length. I was told, as if it constituted an important educational discovery, that ways had been found to train men from the collective farms to become skilled industrial workers in a far shorter time than had previously been thought possible.

Some of the older laboratories had equipment much like that of German or British laboratories of twenty years ago, but some were splendidly equipped and had very skillful machinists, glass blowers, etc. Several large new laboratories were in process of construction and were nearing completion; these are to have excellent equipment. I was shown plans for a new building for the Academy of Sciences about five to ten times larger than the present one.

RUSSIAN PLANNING

The Russians like to plan big projects on a nation-wide scale. The successive five-year plans have been tremendous and successful undertakings. The building of a huge steel industry beyond the Urals long before the war made victory possible. They decided to use mechanical equipment on the farms. The extent to which this was accomplished can be judged by the fact that the Germans captured or destroyed about 200,000 farm tractors, which is about ten times the total number in all Germany.

I was much impressed by the display of Russian-made mechanized equipment in the Victory Parade in Moscow on June 24. The Russian tanks, manufactured in quantity, had shown themselves to be the match of any that Germany had produced and, in the opinion of some experts, they were far better than our own Sherman tanks.

In Moscow I was told that a full sized blast furnace has been operated using oxygen instead of air. A large experimental plant, costing something of the order of $100,000,000, is now nearing completion for the continuous operation of blast furnaces and Bessemer converters. If this work turns out as expected the whole steel industry of Russia will probably be remodeled to adapt it to the use of oxygen, at a cost approximating $2,000,000,000 and with an ultimate large saving in the cost of steel manufacture.

The biggest planned project that the Russians ever undertook was the preparation for war against Germany, extending through the years from 1934 to 1941. The magnitude of this project is demonstrated by the fact that the Russians, with only about 10 per cent of their supplies provided through Lend-Lease, were able to drive back the German armies from Stalingrad to Vienna and Berlin. This is all the more remarkable when we consider that the areas invaded by Germany contained about one-half the population and had about one-third of the industrial output of the whole Soviet Union.

The efficiency of the workers and of the administration at the start of large industrial projects has often been very low, but by well planned educational programs, with energy and enthusiasm on the part of the workers, and with a remarkable system of incentives efficiency was usually rapidly raised to a high level. During my short stay in Russia I was particularly impressed by the tremendous emphasis that is placed on incentives.

INCENTIVES IN RUSSIA

In 1931 the Soviet Government adopted the policy that men should serve according to their abilities and be paid in accord with their services to the state. Piecework rates are in effect in industry and on the farms, with high premiums for work done in excess of given quotas. The rationing of food, clothing, housing, etc., is used also to provide incentives. High honors are awarded to workers of exceptional accomplishment.

In the Academy of Sciences one also sees the working of the incentive system. It is a great

honor to be an Academician, and with the position there goes a salary and often the use of automobiles, etc. The science program is not planned by political leaders but is turned over to the Academy, whose members are elected by secret ballot, and the Academy is presumably held responsible for the success of the program.

During the war the Russians apparently carried on only a rather small scale program in nuclear physics. For example, Professor Joffe in Leningrad started building a cyclotron before the war but work on this was stopped until this year. I was told that this forty-ton cyclotron is to be completed in December 1945. I believe, however, that now the Russians have already started a large atomic energy program and that they will carry this out with great skill and ability. We must remember also that in this work they can get great help from German scientists, trained engineers, and technicians.

The rate at which such a program will progress depends largely upon the motivation. Prestige will play a large role. The Russians are proud of their accomplishments during the war and they believe that their success is due to their system of government. The urge to have their own program of atomic energy will be irresistible.

THE EFFECTS OF INSECURITY

Their present feeling of insecurity, which results I believe from our unfortunate handling of the atomic bomb situation, must be a still more powerful incentive.

The Russians realized better than any other nation the state of insecurity in Europe after 1934. At last in May 1945 the war against the agressors was won and security was attained. All the Russians with whom I came in contact in June expected a long era of peace in which the damage done by the Germans in the devastated areas could be repaired and simultaneously the standard of living could be raised ultimately to a level as high or higher than that in America. Within less than two months the atomic bombs were dropped in Japan.

To understand the effect on the Russians let us consider what American public opinion would now be if we had had no atomic bomb project, but, near the end of the war in Europe, atomic bombs had been dropped on Berlin by the Russians without warning. Would our insecurity have been entirely relieved if the Soviet Government a few months later had announced that it held an increasing stock pile of atomic bombs as a "sacred trust"?

If the Russian insecurity rises until it is comparable to that induced by Hitler they might react much as they did then and put 10 per cent or more of their national income into a huge atomic energy program while we continue to spend 0.5 per cent on bombs and might even dissipate our energies in building a strong but obsolete navy.

RUSSIAN ADVANTAGES IN AN ALL-OUT ATOMIC ARMAMENT RACE

I believe the Russians may reach the second stage, that is, begin to produce atomic bombs, in about three years. Thereafter, however, they might produce bombs faster than we do and so be the first to reach stage 4. In such a race they have certain advantages: they have a large population which can be regimented and can sacrifice standards of living for a long-range defense program; they have a remarkable system of incentives which is increasing their efficiency; they have no unemployment and no strikes; they have already started a more extensive science program than that contemplated by any other government. In Russia they are frankly incorporating into their communistic government some of the best features of our capitalism while we tend to put into our democracy some of the worst features of communism—now discarded in Russia. Thus the efficiency of labor will increase in Russia while in America the stifling of incentives through taxation, the regulation of industry, and unwise labor legislation may impair our capacity to produce. We talk too much about personal security and not enough about opportunity.

I think the actions of the Soviet Union before, during, and after the war have demonstrated that she has no desire for world conquest. She wants primarily security through the destruction of Naziism. We should find grounds for hope and optimism in the fact that the fundamental interests of Russia and the United States are so nearly identical.

We need, however, much better contacts with one another. Edgar Snow, writing recently from Moscow, stated that there are only two hundred sixty Americans in all the Soviet Union. Molotov said on November 6: "Acquaintance with the life of other nations would certainly be of benefit to our people and would broaden their outlook." I hope that this marks the beginning of a new policy

which will facilitate travel of Russians to the United States and permit the circulation of American newspapers and magazines in Russia. Another good sign is that English is to be taught to all Russian children.

Changes are taking place rapidly in Russia. Family life is now valued; divorces are hard to get. Efficiency of education has been improved by having separate schools for boys and girls. Churches can be opened wherever the people want them.

The most important change is the abandonment of all plans for fostering world revolution—which have so long made communism feared in other countries.

The Russians are shrewd bargainers with many of the characteristics of David Harum. During negotiations one is kept guessing as to their intentions until the time for decision has arrived and a contract is signed. Then they live up to their commitments scrupulously.

I anticipate that before the goal of effective world government is reached we will meet a series of obstacles which will often seem insuperable, but, because what we both seek is in the common interest, the difficulties one by one will clear up unexpectedly.

Above all we will need a spirit of mutual tolerance. Russian and American ideas regarding freedom of speech, freedom of the press, and democracy are often very different. Judging from the actions of the House Committee on Un-American Activities our own ideas on freedom of speech are somewhat fuzzy. The Russians seem to believe that they alone have real democracy—"in other countries in which society is divided between the exploited and the exploiters true democracy is impossible, even though it is proclaimed by constitutions."

Under such circumstances we should not expect to establish our form of democracy in Japan while protesting against democracy of the Russian type in Bulgaria.

By recognizing that Russia has as much right to her form of government as we have to ours we may hope to come to an understanding and agreement on world policies. Persevering along the road toward world government with a spirit of fair play we may in fact ultimately "banish the scourge of war from the earth."

FRANKLIN MEDAL LECTURE

ATOMIC ENERGY AS A HUMAN ASSET

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(Read November 16, 1945, in the Symposium on Atomic Energy and its Implications)

It is with high appreciation combined with a deep sense of humility that I accept tonight the Franklin Medal of the American Philosophical Society. Coming as it does from my colleagues whose respect is to me a matter of the greatest value, you must know that this honor is most highly appreciated. Yet the inscription on the Franklin Medal reminds one of virtues which, though called for by the critical times through which we are passing, are scarcely to be found. Benjamin Franklin himself combined the qualities of scientist with those of statesman in unusual degree. Now, in the age of atomic energy, such a combination is needed by the world as never before.

It is with diffidence that we who have been working on the technical aspects of atomic energy present before a group of experts such as are here tonight our amateur thoughts with regard to its human implications. Yet action is needed, and only by boldly presenting our thoughts for discussion can a reasonable basis for such action be reached.

The ability to release atomic energy gives mankind great new powers. These powers can be used for good or ill. The first use of atomic energy was as a bomb whose explosion stopped short a tragic war with the probable net saving of some millions of lives. Its terrific military destructiveness has made it necessary for us to consider afresh how we may avoid future wars. The dramatic demonstration of its explosive power has however drawn attention away from the significance of atomic energy to our industry, our habits of life, and our culture. It is in such peacetime consequences that atomic energy will eventually mean most to man.

The atomic age has started as a period of keenest rivalry. The rivalry is between nations and social systems. The prize to be won is prosperity and world leadership. It can include peace and security. If only we agree to place war beyond the power of nations, the race is sure to make life of greater value. Such is the prospect of a world strengthened by unlimited power from atomic fission and forced away from war by the examples of Hiroshima and Nagasaki.

I want tonight to consider the human consequences of the release of atomic energy in three major directions. First is its effect on war and the world's political structure. Second is its application to the practical tasks of peace. Third is its effect in changing the form of our social life and customs.

1. HOW SHALL WE PREVENT ANOTHER WAR?

World government has become inevitable. The choice before us is whether this government will be agreed upon or whether we shall elect to fight a catastrophic third world war to determine who shall be master. Unity by agreement will bring greater life. Unity forced by another war will bring death to many millions and disaster to all mankind.

The primary function of this world government must be to prevent international war. With regard to its economic and cultural life the world has during the past century been developing into a unit in which the welfare of each person depends intimately upon that of the rest of humanity. We have indeed become "members one of another." Such development has not however resulted in political world unity. The great destructiveness of an atomic war, even to the victor, makes it necessary now for self-preservation to insure peace. In a quarrelsome world the only means of insuring peace is, however, for the nations to set up an international police force which monopolizes the power to wage war.

Now for the first time however it becomes feasible for a central authority to enforce peace throughout the world. Before World War II many parts of the earth were difficult of access by a world police. If not a Maginot Line, at least a strong fighting front could keep out a policing army.

During the time required to bring this policing army to the scene the defense of the recalcitrant group could be strengthened.

Today this is changed. Fast airplanes, long range rockets, and atomic bombs have now solved the technical problem of bringing to bear on any area at any time whatever destructive force may be required to quell resistance. A central authority having virtual monopoly of these major means of warfare can now be equipped to enforce international peace.

The fact is that the United States now has in its possession a sufficient monopoly of the weapons needed for such policing that it might be able to act in this capacity of world police. That we do not set ourselves up as the world governors is simply because we do not want the job. We feel that world control is the world's business, not ours. We know that, if we should use armed force to prevent other nations from fighting when our own interests were not directly threatened, we should be considered meddlers and should gain only the fear and hate of other nations. We should prefer to withhold our fighting power unless our own safety is directly threatened, and confine our policing activity to our own reasonable share in keeping order within nations that are not now able to look after their own interests or that may become dangerous to us if not kept under control.

Nevertheless, looking ahead it is clear that no mere strengthening of our own might can keep us safe. Our safety cannot be kept secure by our own military development without international control of the new weapons. Whatever our strength, others also can arm so as to inflict upon us disastrous damage if war should come. What is needed is an agreement which will make our safety much surer than could result from our own armed might and which will at the same time provide for elimination of international wars elsewhere throughout the world. It is such an agreement that we should seek, sincerely, with determination, and with faith that it can be attained with reasonable promptness. The important step that has just been made in this direction by the President of the United States and the Prime Ministers of Great Britain and Canada should be welcomed by the entire world.

I am not much concerned with the precise answer to the question of how long it would require before other nations could be prepared to challenge us with atomic weapons. I know they will not do so for the next five years. After twenty-five years, unless some mutual agreement prevents their development, such countries as Britain, Russia, and France could arm themselves with weapons similar to ours if they should want to spend the necessary effort. The time required would not be greatly affected by whether we hold to our own secrets or not. It is in any case only a small part of the lifetime of our nation that would elapse before we should be faced with the awful possibility of an atomic war.

As has been seen by the heads of our governments, now is the time when international agreements can best be made to prevent such a catastrophe. Other nations have not yet developed a pride in their atomic might which could give them dreams of world mastery. Our own effort has paid for itself many times over by stopping the course of World War II. All nations are now laying plans for the postwar years, and it will be much easier to shape these plans now on the basis of world government than to stop the wild development of a renegade nation by imposing emergency military controls after it is set in its course.

It may be worth reviewing just what we mean when we refer to the great destructiveness of war in the age of atoms. If the future demands it, science sees no reason to doubt that atomic weapons can be made that are related to the present atomic bomb much as the block buster is to the blunderbuss. Yet even the present atomic bomb is a highly effective weapon. If one bomb will devastate four square miles and damage a hundred square miles, how many bombs are needed to destroy all of a nation's concentrations of fighting and industrial facilities above ground? Will it be 100, 1,000, or 10,000? That is a question for the military to answer. It has been demonstrated that whatever bombs are required can be produced and delivered to their targets.

Let us try to imagine what may be expected to happen if a war between two major powers should break out in 1970. We may assume that by this time both sides will have such weapons in whatever amount they consider necessary and of greater destructiveness and variety than those now possessed by the United States. Because of the enormous advantage of surprise, Pearl Harbor tactics will be employed. Jet-propelled planes or rockets with atomic warheads will be sent without warning at each of several hundred of the enemy's major production centers. No city of over 100,000 population will remain as an effective operating center after the first hour of the war.

At least ten per cent of the attacked nation's population will be wiped out in the initial blow. If this nation elects to fight back, rockets and planes from hidden installations will carry the reply. The attacker in this case can expect no mercy. Though his citizens may have immediately moved underground, his great cities as well as his surface production plants will be annihilated. The fighting will continue until one side chooses to surrender or is unable to resist its opponent's army of occupation.

If the United States should be party to such a war, we should expect Philadelphia, with such neighboring cities as Reading and Wilmington, to follow Hiroshima and Nagasaki into oblivion. With the destruction of these cities we should expect about one out of every four of their inhabitants to be killed. If our nation should eventually win, what would we have gained? Perhaps the control of the world. But of what value would this be with our civilization gone and our population decimated?

No feasible means of preventing the bombs from striking their targets has yet appeared on the horizon. Only two countermeasures have so far been proposed. The first is to disperse our cities, preferably into hilly regions, so that more bombs will be required to destroy them. The second is to place all military installations and essential industries underground and provide emergency underground shelters for all the population. Clearly such measures will seriously interfere with our normal life. So indeed was it inconvenient in the middle ages to live in a castle on a hilltop; but safety in a world of robbers demanded such a life. Similarly now, until positive assurance can be obtained of security through an international military force, we have no alternative but to prepare such shelters and scatter our population. Death is worse than inconvenience.

We must keep in mind that, when all are armed with atomic weapons, no superiority of one nation can free it from danger of great damage by another. One man may own a .22 target pistol and another a high power hunting rifle. But neither is insurance against murder by the other. The insurance is to take away both guns, or the fear of punishment by the police, or most surely of all the development of a social conscience for which murder becomes unthinkable.

Is there then any procedure which can free us from the threat of annihilation? I believe there is. It makes, however, the hard demands of sacrifice of national sovereignty and of faith in other peoples that will give them a share in the responsibility for our own security.

In the statement issued yesterday by the heads of the governments of Great Britain, Canada, and the United States plans are laid looking toward "entirely eliminating the use of atomic energy for destructive purposes and promoting its widest use for industrial and humanitarian purposes." They "emphasize that the responsibility for devising means to insure that the new discoveries shall be used for the benefit of mankind, instead of as a means of destruction, rests, not on our nations alone, but upon the whole civilized world."

Let us suppose that the United States, Russia, and Britain agree to transfer their own total power to wage international war to a joint Military Commission. It will be better to include France and China as the other permanent members of the Security Council so that the Military Commission can function within the framework of the United Nations Organization. This Commission will have placed under its orders the united armies, navies, and war weapons of the member nations. Its charter will give the Military Commission the responsibility for stopping any armed conflict between nations that may arise, including wars in which the member nations are themselves participants. This responsibility can be carried out since the major nations will have contributed to the Commission all of their own fighting strength except that needed for their internal policing. To be effective it seems obvious that the actions of the Military Commission cannot be subject to the veto power of any single nation but must be controlled by the joint action of some such group as the Security Council. For concreteness we may suggest further that this Commission have its seat in Canada, with its headquarters at either Ottawa or Vancouver. Canada will accordingly be the home ground of the combined armies, the home waters of the combined navies, and in its vast territories will be dispersed the atomic weapons of the member nations ready for use in case of emergency.

As thus envisaged, the military strength of the Commission would be so great as to make hopeless the effort of any individual nation or group of nations to challenge its power. At first all of the strength in atomic weapons would be contributed by the United States. The other member nations would, however, contribute armies and

planes and guns according to their proportionate share.

When the agreement is reached to the satisfaction of the member nations, the "know-how" for producing atomic weapons would be passed on to the Commission which these nations entrust with their united military power. From then on there would be no reason why atomic bombs should be made by any other group, here or in any other country. Nor is there any reason why until such an agreement is reached the technical secrets of atomic weapons should be released from the countries that now have them.

The far-reaching agreement here suggested is perhaps one that cannot be attained at one step. Time will be required to make the needed readjustments of our thinking. But the terrible threat of atomic war which Mr. Oppenheimer described so graphically this morning is upon us, and makes it necessary for us to make these readjustments before time runs out.

In the exploitation of the peacetime uses of atomic energy each nation will need to give suitable assurance to the others that its own control of its atomic industry is such as to prevent the malevolent development of weapons by any group within its borders. It is essential that such assurance include provision for the inspection to any extent that may be necessary by representatives of the international Commission.

May I note parenthetically that to provide a mechanism for such control within our own country is an important reason why the Administration at Washington has urged the prompt passage of the atomic energy bill now before Congress? It is vital to the furtherance of our international discussions that we thus first put our own house in order. The legislation is prompted also by the urgent need to provide for keeping our present program of atomic production and research from disintegrating.

There has been no difference between the scientists who shared in framing the bill and those who have criticised it regarding the need for maintaining freedom of research and encouragement of scientific work. There has been a difference as to who should set the rules and by whom the rules should be administered. I personally felt that the original bill, in its anxiety to control unbridled and dangerous misuse of atomic energy, failed to recognize adequately that the nation's future safety depends little upon keeping secrets but is critically dependent upon continued vigorous growth of nuclear science and industry.

On its merits I believe an informed and unprejudiced observer must consider the bill in its present revised form a reasonably good one for the purpose of promoting and controlling research in and use of atomic energy. It is in my opinion much more important to make this bill, or one of similar intent, promptly into law than it is to polish up its political and administrative rough spots. If the United States, which is now using atomic energy, can show that its development can be encouraged under conditions of control that will ensure to the world that it will not be misused, we can then reasonably ask other nations to give similar assurance. It is very important that the scientists give Congress what aid they can in completing this legislation promptly.

Returning to the subject before us, we are proposing that international wars be outlawed and that responsibility for preventing wars be placed in an international Military Commission that will act under the direction of the Security Council of the United Nations Organization. This Military Commission, with its headquarters perhaps in Canada, will monopolize the armed forces of the nations that enter the agreement, except those needed for internal policing. Under its supervision atomic weapons will be produced solely for its own use. The member nations will undertake to prevent the illicit production of fissionable materials within their own boundaries, and this will be supported by permitting complete inspection of their activities by agents of the Military Commission.

If the nations follow such a procedure with courage and determination it would seem possible to ensure the banishment of international wars. It will then be possible to develop with assurance the peaceful fruits of atomic energy.

Two alternatives have been suggested to this idea of preserving our safety through an armed international Commission. One is atomic disarmament. The other is maintaining our own strength on a conclusively higher level than can be attained by any combination of other nations.

I am convinced that atomic disarmament would be a fatal mistake. The proposal we have been discussing calls for the resignation by every individual nation of the right to make and possess atomic weapons; but it makes this outlawing effective by placing atomic weapons at the disposal of the United Nations Security Council.

An agreement to stop producing atomic bombs would only make it possible for some ambitious nation to develop them with the hope of gaining the mastery of the world, and our destruction would be the result.

For a number of years I believe we could as a nation maintain military strength greater than any group that might oppose us. Such a policy would however tend to unite the world against us, which would in the long run be disastrous. It is furthermore doubtful whether over some peaceful decades our nation would continue support of our armed forces adequate to maintain a high level of superiority. We should then become vulnerable to the nation with the long harbored grudge or the newly developed commercial rivalry.

The answer is rather to outlaw war itself. And this can be done by a strong world "police" which has at its disposal more powerful weapons than any recalcitrant nation can hope to acquire.

It is clear, however, that while working for such an agreement for a united international armed force we, as well as other nations, cannot avoid the policy of maintaining our own armed might at a level that will make attack by a potential enemy unprofitable. When our efforts for agreement are successful, our weapons and an appropriate share of our army will be turned over to the Commission. For the time being only we are able to produce such weapons, and it is our task to see that they are made available for this world "police." Thus the Commission will start with the strength necessary to fulfill its responsibilities. If by some mischance the attempts at an agreement should fail, our strength will be doubly needed to discourage attack from any potential enemy.

There is thus real hope that another atomic bomb may never be used in war, and thanks in part to atomic weapons that international war itself may already be obsolete.

2. THE PEACETIME IMPLICATIONS OF THE RELEASE OF ATOMIC ENERGY

Enough regarding the destructive uses of atomic energy. Of much more interest is its use as man's willing servant. In the long run it can hardly be questioned that the peaceful applications of atomic energy will be those that will most profoundly affect our lives. What these important applications will be is, however, as difficult to predict as it would have been a century ago, just after Faraday laid the scientific basis for electrical engineering, to tell the future meaning of electricity. At this moment the obviously great field open to atomic energy is that of production of useful heat and power. We also see important though limited medical and industrial applications of radioactive materials, artificially produced by atomic chain reactions. Perhaps more significant than either are the new vistas that will be opened up by scientific experiments that make use of the by-products of atomic fission.

Such has indeed been the case with such discoveries as x-ray. Fifty years ago it was evident that x-rays were useful for "seeing" through objects, such as the human body, which are opaque to ordinary light. It could not be predicted that x-rays would become a powerful weapon in the fight against cancer, or that researches made by x-rays would reveal the electron and with it give us the radio and a host of electronic devices.

Such unforeseen developments are the result of every great discovery of science. It will nevertheless be worth noting some of the definite practical applications of atomic energy that we can now see clearly before us:

At present, controlled atomic power in the form of heat is in continuous production in large quantities at several plants, especially those at Oak Ridge, Tennessee, and at Hanford, Washington. The heat from these plants is a by-product, and is carried away in the one case by air and in the other by a stream of water. The useful product is neutrons which are used in the plants as a means of transmuting certain chemical elements to others of specially useful characteristics. Of these transmutation processes the most important one is that of uranium into plutonium. Previous to the fission chain reaction the most abundant source of neutrons was the cyclotron which operates on electric power. Per kilowatt of energy used, the fission chain reaction gives some 10,000 times as many neutrons as a cyclotron, and it is not difficult to make a fission chain reaction plant that delivers 100 times as much power as is used by a cyclotron. This means that right now we are using large amounts of atomic power many times more efficiently for the particular process of producing neutrons than the best electrical machine that we have been able to devise.

Looking to the future, we may expect the use of neutrons as a means of producing new elements by transmutation to become of increasing importance. Plutonium is a concentrated source

of available energy and will be a valuable material for peaceful purposes as well as for building weapons.

Other artificial radioactive elements, especially radioactive ones, will also find use in medicine, in industry, and in many branches of science. It is yet too early to see clearly how important these uses may become.

We have not yet built an atomic power plant that is generating electrical power. This is merely because we have been engaged in winning a war and there has been no serious shortage of electric power. If there were sufficient demand for a demonstration, a reasonably efficient plant using super-heated steam for driving a turbine could be put into operation within a year. Before, however, such plants can be made economical competitors with existing practice, a number of years' development will be required.

While there are several other possibilities, the most obvious method of producing power from atomic fission is to heat a cooling agent such as air or steam or liquid metal in the chain reactor unit and pass this heated coolant through a heat exchanger which heats the steam for driving a turbine. Beyond the heat exchanger of such a plant everything would be done according to standard practice. Up to the heat exchanger all the design requires new features, among them protection against the extreme radioactivity of everything, including the coolant, that has been exposed to the neutrons.

The chain reacting unit itself can assume many forms. The one essential is that it shall contain a fissionable substance such as uranium, either in its natural state or, if a small unit is desired, enriched with additional U–235 or plutonium. H. D. Smyth, in his official report, has described in some detail how this active material can be combined with a moderator such as carbon or beryllium or heavy water so as to bring about the chain reaction.

The large atomic power plants now used for producing plutonium have in them many tons of natural uranium and graphite. By using uranium containing more than the usual fraction of U–235, chain reacting units have been built that are of much smaller size.

There is, however, a lower limit to the size and weight of an atomic power plant that is imposed by the massive shield needed to prevent the neutrons and other dangerous radiations from getting out. Next to cosmic rays, these radiations are the most penetrating that we know and, for a plant designed to deliver for example no more than 100 horsepower, are enormously more intense than the rays from a large supply of radium or an x-ray tube. To stop them, a shield equivalent in weight to at least two or three feet of solid steel is needed. There are basic laws of physics that make it appear very unlikely that a lighter shield can be devised. This means that there is no reason to hope that atomic power units for normal uses can be built that will weigh less than perhaps fifty tons. Driving motor cars or airplanes of ordinary size by atomic power must thus be counted out.

Prominent among the advantages of atomic power are the extraordinarily low rate of fuel consumption and consequent low cost of fuel, the wide flexibility and easy control of the rate at which power is developed, and the complete absence at the power plant of smoke or noxious fumes. With regard to fuel consumption, when completely consumed, the fission energy available from a pound of uranium is equivalent to the energy obtained from burning over a thousand tons of coal. With the prewar price of uranium oxide at roughly $3.00 per pound and of coal at $3.00 per ton, this would mean the economical use of uranium as fuel if only one part in a thousand of its available energy is used. Actually we should expect the first plants built for producing atomic power to be considerably more efficient than this in their use of the fission energy which would mean a substantial cost advantage in favor of uranium. One must consider also, however, the need to purify and fabricate the uranium into the desired form. For certain types of power plants under consideration, some separated U–235 is required and this is expensive. Attempting to consider all such factors, it appears that the fuel cost of the atomic power plant of the future will nevertheless be small as compared with the corresponding fuel cost of a coal burning plant.

In considering the economic aspects there are, however, many other factors. It is not really possible for these to be explored until we have actual experience with atomic power plants. First is the capital cost. Clearly, if one must charge against the capital cost what is spent in research and development, this cost is very high indeed. If, however, one looks down the line to a billion dollar a year national industry based on atomic power, the nation can afford a considerable investment in the research and development required to bring this industry into being. When

this development is completed, it appears not unlikely that the cost of building and maintaining a large scale atomic power plant may compare favorably with that of a coal consuming plant of the same capacity.

Much remains to be learned, however, regarding the metallurgical and other technical problems involved in constructing a successful plant to transform fission energy efficiently into high temperature heat. The materials to be used may be expensive. The designs are, nevertheless, essentially simple. An inherent advantage of the atomic power unit is that the heat sources, i.e., the uranium blocks, can readily be maintained at any desired temperature regardless of how rapidly the heat is being removed. This means that a relatively small sized heater unit will be needed and that corrosion due to excessive heating is controllable.

The terrific blasts produced by the atomic bombs have led to unwarranted fear of accidental explosions resulting from the normal use of atomic power. Explosions such as destroyed Hiroshima cannot occur accidentally. Such explosions must be carefully planned for. The dangers of explosions of the "boiler" type with an atomic power plant are about the same as with a steam plant, which is to say they are practically negligible if the plants are designed and handled by competent engineers.

There is, nevertheless, real possibility of damage to health of the operating personnel from ionizating rays emitted by the plant itself and by all materials that are taken out of the plant. These materials could also become a public hazard. This is the problem of the health of radium and x-ray workers on a grand scale. That the problem can be solved is shown by the fact that in all of the operations of the existing half dozen or more such plants, some of which have now been working for years, not a single serious exposure has occurred. This, however, is due to the thorough inspection and vigilant care given by the health staff headed by Dr. Robert Stone. In some of the experimental work we have not been so fortunate. Until we become much more familiar with nucleonics than we are at present, atomic power plants can be safely operated and serviced only with the help of health supervisors who are familiar with radiological hazards.

All of this points toward using atomic power first in relatively large units where careful engineering and health supervision can be given. An obvious suggestion is its application to the power and heat supply of cities and of large industrial plants. Within ten years it is not unlikely that the power companies designing new plants for city service will be considering favorably the use of uranium instead of coal for purely economic reasons.

This of course does not mean that atomic power will put coal out of business. Each will have its own field. For small heating units, such as the kitchen stove, atomic power has no place. If our national economy grows as it should, coal as a chemical agent, as for example in blast furnaces and preparation of organic chemicals, will increase in importance.

From the point of view of the national economy the introduction of such a new source of power is a clear gain. If it will lessen the cost of heat and power to our cities, it will be a stimulus to every industry. If it reduces the pall of winter smoke, it will be a boon to us all. If it gives cheap power where industry and agriculture need it but cannot now get it, it will extend our economic frontiers. These are possibilities that lie immediately before us.

3. ATOMIC ENERGY AND OUR WAY OF LIFE

Atomic energy is just one more step along the path of technological progress. It may, however, be the supreme gift of physical science to the modern age. Clearly its value will be determined by the use to which it is put. It is especial worthy of note that, along with other technical advances, the effect of atomic power is to force human society into new patterns. This need for human growth to meet the responsibility of atomic power is the basis of Norman Cousins' striking statement that "modern man is obsolete."

Let me note briefly three such effects of technology on society that can be clearly recognized. These are, first, toward greater *cooperation,* second, toward more *training and education,* and third, toward evaluating ones life in terms of *service* rendered to the community.

First, the society that is adapted for survival in the modern world is one in which an increasing degree of *cooperation* occurs between diverse groups spread over ever larger areas. As an example, consider the atomic bomb project, in which about a million people of all types and descriptions and spread throughout the nation worked together to gain a needed result that could be achieved only by a great coordinated community.

In no field is the growing importance of such cooperation more evident than in that of scientific research. Faraday, a century ago, was one of the first professional scientists. Working by himself, he covered the whole field of electricity and much more besides. Sixty years ago Thomas Edison organized what was perhaps the first research team to work with him at Menlo Park. Now our country has thousands of research laboratories. From 1900 to 1940 our universities developed organized research groups for studying specific problems. Astronomers built specialized observatories. Research centers grew for studying diseases. Teams of physicists built cyclotrons and surveyed cosmic rays over the world. When the war came cooperative research became of greatly increased size and effectiveness.

The development of the methods for producing plutonium is typical. At the peak there were engaged on this one problem roughly five thousand laboratory workers in more than seventy locations studying its different aspects. Not only theoretical physicists and nuclear chemists were needed. Equally vital were corrosion experts and metallurgists and haematologists and meteorologists, laboratory technicians, mechanics and office workers of many kinds. No one person could be skilled in every field or understand even the meaning of the answers to the many problems. But somehow the group mind integrates such knowledge into the useful form that results in a process that successfully produces plutonium.

There remains, happily, a valuable place for the individual research man who masters and advances his own limited field of study. His specialty, however, is of little value except as a part of a broader field. More and more we find that even in a limited field a team of men with different specialties working together does the most effective work. New thoughts develop in their discussions. More refined techniques are available. A team which thus supplies a combination of originality and special skills is the pattern toward which research is moving.

Cooperation is thus the very life blood of a society based on science and technology. Such a society is necessarily made up of specialists, not only scientists and engineers, but skilled laborers, salesmen, administrators, educators, and legislators. Working alone such specialists are useless. When their work is coordinated they form a society of enormous strength. It is a major source of our nation's vitality that we have so many diverse elements in our population. Each has its place among the many specialties. What the society of an atomic age cannot permit is the development of antagonisms between these groups that will prevent effective cooperation. To love our neighbors is becoming the condition of survival. And our neighbors with whom we work are to be found in all divisions of society throughout the entire world.

As the second evident effect of technology on society, consider the need for ever increasing *training and education*. It is because of the mechanical skill of many millions of workers, the know-how of our many technical men, and the administrative skill of our industrial and military leaders that our country has come out ahead in this war as in the last. It is no disparagement of the American engineers who have done these great tasks to point out that most of the new wartime developments that have led to victory, such as radar, submarine detection, rockets, and the atomic bomb, have had to be led by men whose scientific knowledge is far in advance of that supplied by our technical schools and industries in the training of engineers. To compete in the modern world more people need more training. Nor is technical training all that is required. Of greater importance is more education for leadership. In a democratic society that is forced into a position of world prominence our citizens as well as our leaders need to understand the problems and human needs of all the nations.

This pressure for more training and education applies at all levels. Automatic machinery performs an increasing number of routine jobs. The demand for skilled mechanics to make the machines is thus increasing while that for unskilled labor falls off. The growing complexity of society multiplies rapidly the demand for all kinds of persons trained to keep the work coordinated. These range from typists to administrators. Of those whose overall view of the needs of society is adequate to guide wisely an industry or the growth of a community there is an acute shortage.

The result is more students wanting more extensive education in schools and colleges. Professional schools are becoming graduate schools. More research men will want to carry their studies beyond the doctor's thesis. The interruption of our college education during the war places our nation at a temporary disadvantage with regard to highly trained young men and women and is for the moment keeping down the enrollment in our advanced classes. All indications are, how-

ever, that the postwar pressure on our institutions of higher learning will increase and continue. There is growing interest likewise in all aspects of adult education as our citizens strive to keep themselves abreast of the rapid changes of the times.

The third and perhaps the most remarkable trend is an increasing concern that one's activities shall *contribute to the welfare of society.* It is more difficult to establish this trend by citing examples than it is to show the increase of cooperation and of education. But it is, I believe, no less real. The ancient high regard for the "holy man" who retired to a monastery and separated himself from society finds little sympathy in our modern life. Reading of American colonial history shows that the freedom for which our forbears fought was primarily the right to live their own lives in the pursuit of happiness without unnecessary restrictions, not primarily the opportunity to shape a better society. Now both capital and labor strive to justify their position in terms of the usefulness of their contribution to society, and our nation has fought a war with unparalleled unanimity because our loyalty to the common cause made us ready for any sacrifice.

We have not had in this country prominent movements similar to that in Germany where the youth was whipped to patriotic ardor by the call to lose one's self in the greater good of the state. Nor has any "cause" in this country perhaps met with the wide response the Russians have given to communism as a political system in which each person consciously works for the good of all. Yet Americans respond to many calls to service. As members of scientific societies we are aware of our own increasing attention during the past generation to the social responsibilities of science and scientists. The present active concern of the scientists about the political disposition of the atomic energy problem is apparently only a representative example of the anxiety of everyone in the nation that with the great issues with which humanity is faced his own actions may help rather than hinder a good solution. The greater powers placed in our hands by technology seem indeed to make us more acutely aware of our responsibility to use these powers for human ends that go beyond ourselves.

Typical of the forces working in this direction is recognized need that our form of society must attain its fullest strength if it is to survive in the fierce competition of the postwar world. We have come to realize however that our strength lies in the many millions of our citizens who are working efficiently and loyally at the nation's tasks. Widespread education, encouragement of each individual to seek for the place in the game where he can play best, opportunity for advancement and leadership—all these have helped to strengthen our society. Self-preservation demands that all possible effort be given to enable and encourage every citizen of the country to contribute his best to the needs of the nation. To attain this result, cultivation of the spirit of service is of first importance.

The evolutionary law of the survival of the fittest applies to societies as well as to individuals. According to this law the society of the future will inevitably advance along these lines of cooperativeness, of education, and of individual concern with service toward the common welfare. If selfish interests or an ill-adapted form of government should prevent our growth along these lines, some other nation or group that can develop thus more rapidly will pass us by.

You will note that these factors which give strength to society are precisely those that characterize the highest type of citizen. Cooperation: he likes to work with others on a common task. Education: he has learned to do his own useful task and to share intelligently in solving public problems. Service: the central objective of his life is to contribute to the common welfare the maximum that his abilities make possible. These also are the factors which make life of greatest value to the individual himself.

My point is this: the release of atomic energy is merely the most recent important step of that steady progression of science that is compelling man to become human. He must pay careful attention to cooperation, education, and service for the welfare of society if he is to thrive under the conditions that science imposes. If we will let ourselves grow as thus indicated, the civilization of the atomic age promises to be the richest that history has known, not only with regard to material bounty, but also in its cultivation and appreciation of the truest human values.

How then are we justified in describing atomic energy as a human asset?

First, atomic energy now supplies for the first time weapons which make it possible for a centralized world government to prevent wars between nations. Having made war intolerable because of its enormous destructive power, it thus opens the

way for an international organization to prevent war from ever occurring again.

Second, atomic energy is now a source of useful new materials produced by transmutation. It promises to supply us with heat and power available in large quantities wherever needed and thus to open new economic frontiers. New advances in medicine, in industry, and in science are on the horizon.

Third, as the most recent great step in the long progression of advances in science and technology, the advent of atomic energy is forcing mankind along the difficult road to greater humanity. Growing cooperation, education, and spirit of service are evident trends.

The present is thus a time for hope. True, the atomic bomb has brought us face to face with the fact that continued world strife will mean disaster and death. It is however likewise true, and much more worthy of attention, that the way is now open as never before for the world to reach a true unity, with world peace a necessity that can and will be attained.

When our first parents ate of the fruit of the tree of knowledge, they became as gods, knowing good from evil. Much as they longed to return to the garden of innocence an angel with a fiery sword stood in their way. Their only hope for peace lay in work to make the earth give them a fuller life. Somehow the marvel occurred that in their work they became human souls who shared the task of their Creator and came to be called His children.

The same angel with the same fiery sword prevents us from returning to a pre-atomic age. We have no choice but to use our great new powers in the effort to build a better world.

In the fierce competition between social systems in the atomic age the need for strength demands that we enable every citizen to contribute to the common welfare as his abilities may permit. Permanent peace can now be secured if we will work for it. Increased prosperity with broader horizons lies before us. Greater development of the human spirit is the inevitable consequence of the increased responsibility for using our new powers. These are among the greatest of human goods.

GROUNDPLANS AND PRINTS OF THE UNIVERSITY OF VIRGINIA, 1822–1826

EDWIN M. BETTS

Assistant Professor of Biology, University of Virginia

THE University of Virginia had its origin in Albemarle Academy which in 1816 was converted into Central College. Neither institution opened its doors to students. The cornerstone for the first building of Central College, now the front part of the Colonnade Club, was laid on October 6, 1817. In 1819 Central College became the University of Virginia. When the change was effected two pavilions and their adjacent dormitories had been begun.

During the years of 1820 and of 1821 the building program of the University progressed so rapidly that Jefferson was able to write on November 22, 1821, to William J. Coffee of New York,

> I have housed myself now for the winter, and shall not leave my quarters again till the spring, except on occnl [occasional] rides to my hobby the Univ^ty which now I assure you, begins to have a splendid appearce [appearance] even without it's greatest ornam^t the Rotunda, not yet begun.[1]

Jefferson left Monticello on November 29 of the same year to see the University and to attend a meeting of its Board of Visitors of which he was the Rector. Since only two members of the Board were present, the meeting was adjourned to the following day when four members attended. At this meeting the following resolution was passed:

> Resolved, that the superintending committee be authorized to have an engraving made of the groundplat of the buildings of the University, including the library, and so many copies struck off for sale as they shall think proper, and also to engage a good painter to draw a perspective view of the upper level of buildings, to be engraved, yielding to him, for his trouble, the patent right, and paying his reasonable expenses coming, staying and returning, should it be required.[2]

At this same meeting Jefferson stated in his annual report on the progress of the building program to the Directors of the Literary Fund,

> The completion of the buildings of accommodation, which are in four rows of about 600 feet in length each, as may be seen by the plans [fig. 1.] accompanying this report, has been pressed with as much effect as could be expected; insomuch that there are now complete, and in readiness for occupation, six pavilions for the accommodation of the professors, eighty-two dormitories for that of the students, and two hotels for their dieting; and the others will be completed in the ensuing summer. The accounts for the construction of those already finished have been actually settled; and the probable cost of the unfinished has been estimated according to the rates which the others have been found to cost.[3]

Since six pavilions, two hotels, and eighty-two dormitories had been completed there still remained unfinished four pavilions, four hotels, twenty-seven dormitories, and the garden walls.

On December 31, following the meeting of the Board of Visitors, William J. Coffee came to Monticello to visit Jefferson. He was a sculptor and a dealer in ornaments for buildings, and he had furnished articles of this kind for the University, Monticello, and Poplar Forest. Exactly how long Mr. Coffee remained at Monticello is not known. He was certainly there on March 25, for on that day Jefferson paid him one hundred dollars for repairing his paintings.

It was during Mr. Coffee's visit to Monticello that Jefferson began making plans to carry out the resolution of the Board of Visitors to have a groundplan of the University engraved. He discussed with Mr. Coffee the possibility of having this done in New York and of having impressions made from the engraved plate.

Mr. Coffee left Monticello for New York sometime after March 25 carrying with him Jefferson's groundplan of the University. This drawing was made before the Rotunda was begun and before the remaining four pavilions, four hotels, and twenty-seven dormitories, mentioned above, were completed. On May 14 Jefferson set out for Poplar Forest, his home in Bedford County, Virginia. He remained there until May 29.

On June 14 Jefferson, becoming impatient to

[1] *Jefferson papers*, The Library of Congress.

[2] Lipscomb, A. A. and A. E. Bergh, eds., *The writings of Thomas Jefferson* XIX: 399, Washington, Thomas Jefferson Mem. Assn., 1907.

[3] *Ibid.*, 401–402.

learn what progress had been made in securing someone to engrave a plate of his groundplan and print impressions from it, wrote to Mr. Coffee, from whom he had not heard since his departure from Monticello,

I am in the daily hope of hearing from you on the subject of the engraving of the ground plan of our University, as to price and any other particulars you would recommend.[4]

Jefferson received a reply to his letter from Mr. Coffee on July 5 with an enclosed letter from Peter Maverick,[5] whom he had recommended to engrave the plan.

NEW YORK 25, June 1822 [6]

Honor'd Sir:

The receiving a letter from you was a Pleasing favour which I had looked for some time, and in answer as relates to the Engraving of the ground Plan of the University the letter [7] that accompany[s] this will put you in Possession of that you request to know. Mr. M. [Maverick] is a Gentleman of the first Ability[s] in that art in this City and the date of Estimate will show that I had not neglected the favour of your Commission, and the delay, has been from a wish to Inform you of my Progress in the work for the University. . . .

Farther speaking of the Engraving I think the Price a little high much more so than I had any Idea, however nothing less will do have seen two artist (the first and second) rate man the Price I found the same I therefore had no doubt who should have the work should you Conclude to give an order it may be to me or to Mr. M. [Maverick] or should you Please to have the Drawing returned it is in my Possession. The time it would take by the Engraver would be about two months. . . .

Jefferson replied to Mr. Coffee's letter on July 10 and in it accepted Mr. Maverick's proposals for the engraving.

MONTICELLO July 10. 22.[8]

Your favor of June 25. is just received. on consideration of m[r] Maverick's proposals for the engraving of the University I conclude that it be done in what he calls the line manner, which he says will cost 112. D. and continue good for 6. or 8000 impressions. I will therefore ask the favor of you to engage him to do it in that way and when done to have 250. copies struck and forwarded to me by water thro' Col[o] Peyton.[9] he asks on what kind of paper? of the names and qualities of the different kinds of paper I am ignorant, and must leave it therefore to him to have it done on what is very good. he might send me a proof sheet in a letter by mail. the cost of the plate & impressions shall be remitted on reciept of his bill. I will wish him to retain the plate until called for because if we find the impressions sell readily we shall call for more. . . .

By November 12 Mr. Maverick had completed the engraving of the plate and in the letter that follows he enclosed a proof impression of it to Jefferson.

The Honb[le] TH. JEFFERSON

Esteemed Sir

The order received last summer by the hand of M[r]. Coffee could not be completed earlier than this time on account of the prevailing sickness, which caused me to remove from the city for several weeks. I now hasten to forward you an impression of it.

The proof is not perfect, but could not get a better one without delaying it 2 or 3 days longer. hope the execution will prove satisfactory.

You will please instruct me as to the number of impressions you require to be printed and of the quality of paper (that is to say whether it must be sized or unsized, thick or thin)

I am Sir with much esteem and veneration

Your obedient Serv[t]

PETER MAVERICK

NEW YORK Nov[r]. 12[th]. 1822[10]

Jefferson received Mr. Maverick's letter and the proof impression on November 17 and appears to have been well pleased with them. On November 20 he sent the following letter to Mr. Maverick:

[MONTICELLO] Nov. 20. 22.[11]

Sir

I have duly rec[d] your favor of the 12[th]. with the proof sheet of the plan of the University of Virg[a]. you enquire whether the paper for those to be struck off is to be thick or thin? sized or unsized? as to the 1[st]. question the paper of the proof sheet which you sent me appears to me proper. the 2[d] question sized or unsized? I am not able to answer, not knowing the nature & object of the oper[n]. perhaps you can decide what is best on my information that the prints are intended for frames. be pleased to strike off 250. copies & forward them by water to Col[o]. B. P. [Bernard Peyton] at Richmond, retaining the plate till further orders. send me your bill by

[4] *Jefferson papers*, Massachusetts Historical Society.

[5] Peter Maverick (October 22, 1780–June 7, 1831), New York. Engraver and one of the founders of the National Academy of Design.

[6] *Jefferson papers*, The Library of Congress.

[7] This letter from Peter Maverick has not been located.

[8] *Jefferson papers*, Massachusetts Historical Society.

[9] Colonel Bernard Peyton, a Commission Merchant of Richmond, Virginia, was a friend and correspondent of Jefferson.

[10] *Jefferson papers*, Massachusetts Historical Society.

[11] *Ibid.*

mail and the amount shall be remitted thro' Col°. Peyton without delay. . . .

Mr. Maverick completed the printing of Jefferson's plan by December 7 and on that day sent to him an itemized invoice for the finished work. Jefferson received it on December 11 and on December 13 the Proctor of the University paid, "By my draft on Bursar to Peter Maverick $150.00." [12]

Much esteemed Sir [13]

I have this day as p^r^ direction forwarded by water to Richmond to Col Peyton a Box cont 250 impressions of the Plan of the University

hope the whole execution will meet your entire satisfaction. The Plate I have retained as p^r^. y^r^. advise subject to future orders.

I am Dear Sir
Your oblige & humb^e^ Serv^t^
PETER MAVERICK

The Hon^ble^ TH JEFFERSON
NEW YORK Dec. 7^th^. 1822

[Invoice]
The Honb^le^. THOMAS JEFFERSON
to PETER MAVERICK

	D	C
To Engraving a Plan of the University of Virginia	112.	
" Printing 250—d° @ $10	25.	
" Paper for d°	12.	
" Box & cartage	1.	
	$150	

New York Dec. 7^th^. 1822

Jefferson had written to Mr. Coffee on September 30 [14] evidently inquiring of him why he had not received the impressions of the plate. However, before Mr. Coffee had replied to his letter, Jefferson had already received the plans from Mr. Maverick. The letter accounts for their delay.

NEW YORK Jan^y^. 3^rd^. 1823 [15]

Hon^rd^ Sir

The day after receiving your last favour 30 of September I rode over to Mr Maverick.[16] I called on him a five day back and understand, that work is Compleated and in your Possession I hope it does meet with your Entire Approbation. . . .

[12] The Proctor's Report, University of Virginia.

[13] *Jefferson papers*, Alderman Memorial Library, University of Virginia.

[14] Letter of September 30, 1822, has not been located.

[15] *Jefferson papers*, Alderman Memorial Library, University of Virginia.

[16] Jefferson also received a letter from Mr. Maverick on December 23 (Jefferson's Epistolary Record). The letter has not been located.

Figure 1 reproduces the first engraving of the groundplan of the University of Virginia. This groundplan, which is 19½ by 17½ inches in size, shows the University as Jefferson planned it and built it with two minor changes: the steps were not built at each end of the terraces to the Rotunda and another dormitory was added to the southern end of West Range. These changes were made on the revision of the plan in 1824 (fig. 2).

Jefferson bought at least three copies of this groundplan. His Account Book for 1823 records: "July 4. plan of the University. .50" and "Aug. 22. plan Univ^ty^. .25." The Proctor's Report records: "Aug 19, 1824. Tho^s^ Jefferson for 1 plan .50."

By early September of 1824 most of the original two hundred and fifty plans had been sold. Since the first printing of the plan the ten pavilions for housing the professors and the dormitories on the Lawn and the Ranges for students had been completed. In addition to these the walls for the Rotunda had been erected and the dome for it had been built and covered. The University was now almost ready for the admission of students. The opening of the University did not take place, however, until March 7 of the following year.

On September 4 Jefferson wrote to Mr. Coffee,

I write this day to m^r^ Maveric for a further supply of plates of our groundplat, after previously making some small alteration in the engraving.[17]

He did not, however, write to Mr. Maverick on that day as he later stated in a letter to Mr. Coffee on September 19,

when I wrote to you on the 4^th^. I expected every moment to receive one of the sheets of the groundplan of the University as taken from m^r^ Maveric's engraved plate which I meant to forward instantly. I have not yet received it but expect it constantly & shall forward it on reciept.[18]

Jefferson wrote to Mr. Maverick on September 22 at which time he enclosed a corrected copy of the plan (fig. 2) with the alterations mentioned in the following letter.

MONTICELLO Sep. 22. 24.[19]

Sir

In my letter of Nov. 20. 22. I requested you to retain the Plate which you engraved of the University of Virginia until further orders. I am now to

[17] *Jefferson papers*, Massachusetts Historical Society.

[18] *Ibid.*

[19] *Ibid.*

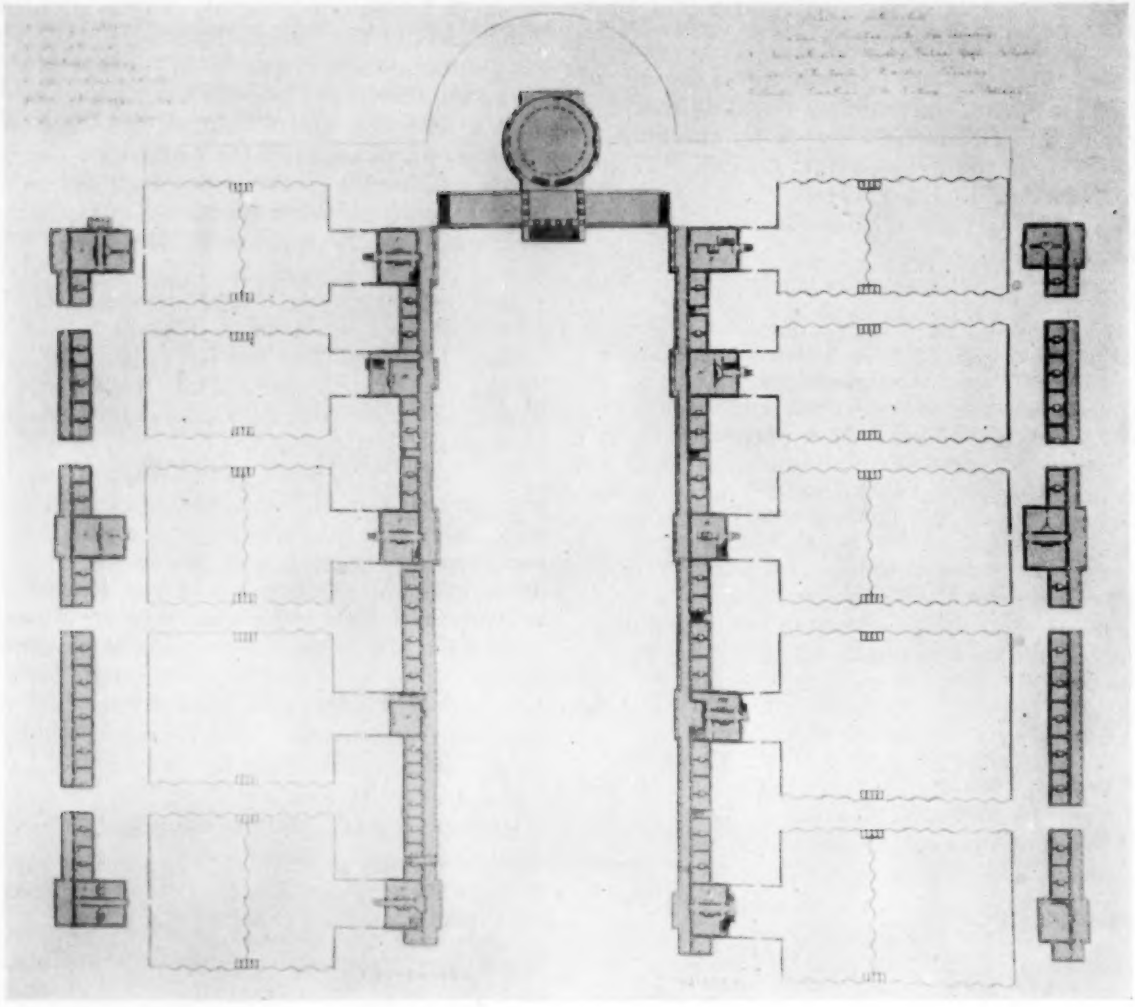


FIG. 1. The groundplan of the University of Virginia, 1822. It was drawn by Thomas Jefferson and engraved by Peter Maverick. See figure 3 for explanation. The indistinct notes in the upper left corner read: No. 1. Doric of Diocletian's baths, from Chambray. 2. Ionic with dentels from the temple of Fortuna Virilis, Palladio. 3. Corinthian, Palladio. 4. Doric of Albano, from Chambray. 5. Ionic with modillions, Palladio's. 6. Ionic of the theatre of Marcellus, dentels, Chambray. The notes in the upper right corner read: No. 7. Doric of Palladio, with mutules. 8. Corinthian of Diocletian's baths, from Chambray. 9. Ionic with dentels, Temple of Fortuna Virilis, Palladio. 10. Doric of the theatre of Marcellus, Chambray. Rotunda, Corinthian of the Pantheon, from Palladio.

desire you to strike off 200 copies more, having first corrected the plate. I send you a copy with the alterations of the engraving which are desired to be previously made. they are as follows.

1st. engrave the Nos. 1. 2. 3. etc. within the dormitories as done in this copy.

2d. add another Dormitory No. 55. as you see sketched here at the left hand bottom corner, exactly like No. 56. at the right hand bottom corner.

3d. make the alteration which you see drawn here between the Portico of the Rotunda and the corner of the Pavilions I. and II. on each flank. I inclose a printed explanation [20] of the drawing from which you will better understand these terms. be pleased to forward the copies by water to Col. B. Peyton, of Richmond under my address still retaining the copper plate, and sending your bill to me by mail, and the remittance shall be made you without delay. accept my respectful salutns.

TH: J.

[20] See fig. 3.

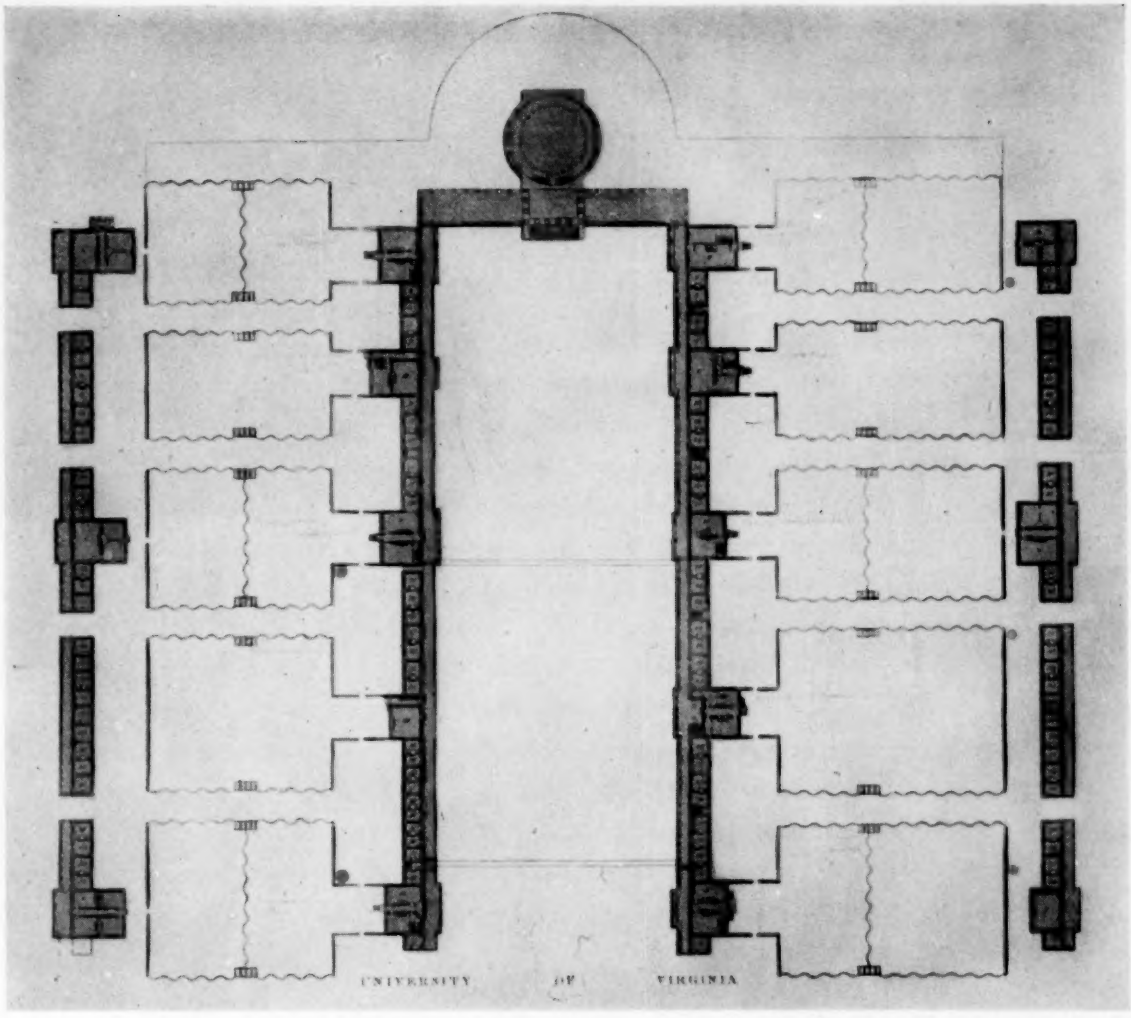


FIG. 2. The groundplan of the University of Virginia, 1825. It differs from figure 1 in that the steps are removed from each end of the terraces to the Rotunda, a dormitory, number 55, is added to the southern end of the West Range, and the dormitories are numbered 1 to 55. See figure 3 for explanation.

Jefferson receiving no word from Mr. Maverick concerning the revised groundplan, wrote to Mr. Coffee on December 9,[21] "I have been expecting also our plates from m[r] Maverick." Jefferson's concern over the plans was justifiable because the opening date for the University was rapidly approaching and prospective students wished to see the plan of the new University. The following letter from Mr. Coffee reassured Jefferson.

NEW YORK Jan[y]. 16, 1825 [22]

That no time might be lost I called on M[r] Maverick the same day I received your favour dated 5. Jan[y]. which came to hand not till the 14[th]. I stated to him your wishes and the following is his answer Viz. that owing to Ill health his business has out of necessity being neglected, that *now* they are in hand and will Positively be forwarded to Richmond from this City in the whole of the following week.

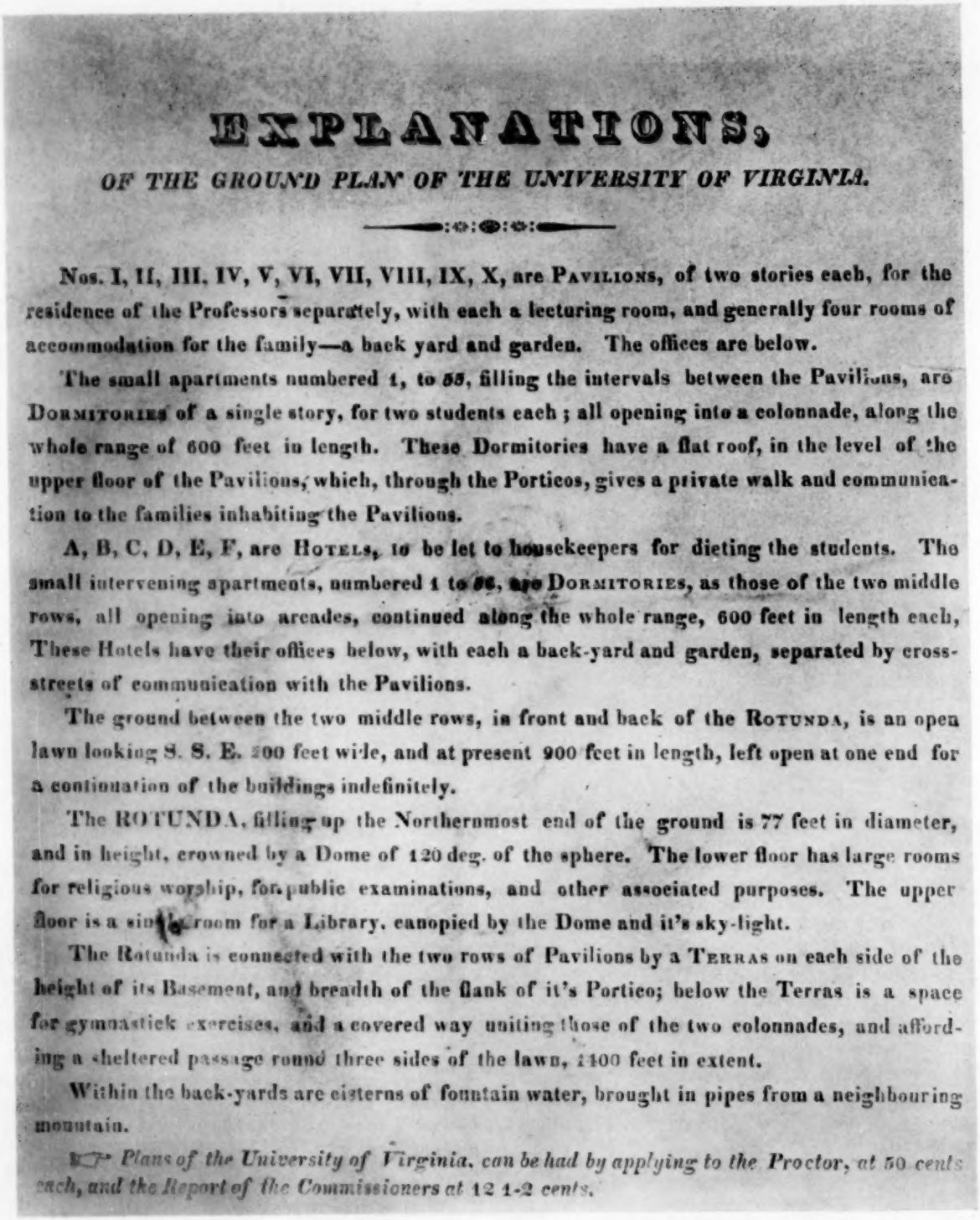
The plans did not arrive, however, until March 3, and on that day the Proctor of the University entered in his books the following statement:

Engraving acc[t] D[r] to Peter Maverick [23]	
For alteration in plate	13
Printing 250 Copys of Plan of the U. V[a]	25
Paper $12.00 Box & carting to 1	13
	51

[21] *Jefferson papers*, The Library of Congress.

[22] *Ibid.*

[23] Proctor's Book, University of Virginia.



EXPLANATIONS,

OF THE GROUND PLAN OF THE UNIVERSITY OF VIRGINIA.

Nos. I, II, III, IV, V, VI, VII, VIII, IX, X, are PAVILIONS, of two stories each, for the residence of the Professors separately, with each a lecturing room, and generally four rooms of accommodation for the family—a back yard and garden. The offices are below.

The small apartments numbered 1, to 55, filling the intervals between the Pavilions, are DORMITORIES of a single story, for two students each; all opening into a colonnade, along the whole range of 600 feet in length. These Dormitories have a flat roof, in the level of the upper floor of the Pavilions, which, through the Porticos, gives a private walk and communication to the families inhabiting the Pavilions.

A, B, C, D, E, F, are HOTELS, to be let to housekeepers for dieting the students. The small intervening apartments, numbered 1 to 86, are DORMITORIES, as those of the two middle rows, all opening into arcades, continued along the whole range, 600 feet in length each, These Hotels have their offices below, with each a back-yard and garden, separated by cross-streets of communication with the Pavilions.

The ground between the two middle rows, in front and back of the ROTUNDA, is an open lawn looking S. S. E. 200 feet wide, and at present 900 feet in length, left open at one end for a continuation of the buildings indefinitely.

The ROTUNDA, filling up the Northernmost end of the ground is 77 feet in diameter, and in height, crowned by a Dome of 120 deg. of the sphere. The lower floor has large rooms for religious worship, for public examinations, and other associated purposes. The upper floor is a single room for a Library, canopied by the Dome and it's sky-light.

The Rotunda is connected with the two rows of Pavilions by a TERRAS on each side of the height of its Basement, and breadth of the flank of it's Portico; below the Terras is a space for gymnastick exercises, and a covered way uniting those of the two colonnades, and affording a sheltered passage round three sides of the lawn, 1100 feet in extent.

Within the back-yards are cisterns of fountain water, brought in pipes from a neighbouring mountain.

☞ *Plans of the University of Virginia, can be had by applying to the Proctor, at 50 cents each, and the Report of the Commissioners at 12 1-2 cents.*

FIG. 3. "An explanation of the ground plan of the University of Virginia." See figures 1 and 2.

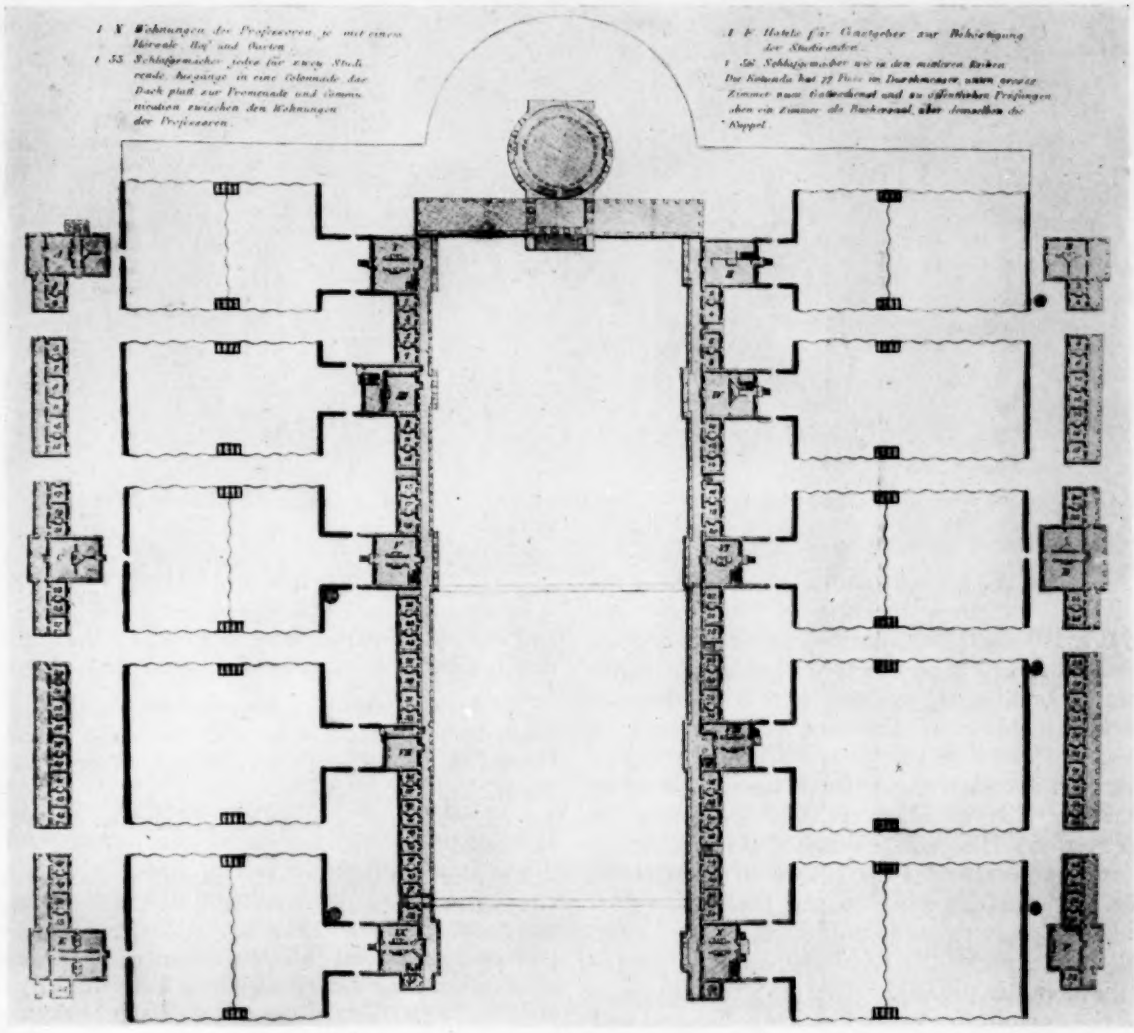


FIG. 4. The groundplan of the University of Virginia, 1825, as reproduced by Karl Bernhard.

On March 29 Jefferson entered in his Account Book "pd. A. S. Brockenbrough [Proctor of the University] for a plate [plan] of Univ^{ty}. .50."

This revised groundplan (fig. 2) shows the University as Jefferson finally built it. The steps at the east and west ends of the terraces to the Rotunda, shown on the original plan (fig. 1), were left off and the dormitory number 55, at the southern end of West Range was added. Numbers were also added to the dormitories instead of omitting them as in the original plan A further change was the deletion of the description of the pavilions at the top of the plan.

An "Explanation of the Ground Plan of the University" (fig. 3) was printed to accompany the plan. The two were sold together for fifty cents [24] to students and other interested people.

Karl Bernhard, Duke of Saxe-Weimar-Eisenach, visited the University and Monticello in the month of November, 1825. When he returned to Germany he published, in 1828, a book [25] on his grand tour of America and in it gave an interesting account of his visit to the University, and also reproduced a copy of the groundplan of 1825. The plan was probably given to him by Jefferson (fig. 4).

[24] See Proctor's Books for statements of plans sold to interested people.

[25] Bernhard, Karl, Duke of Saxe-Weimar-Eisenach, *Reise Sr. Hoheit des herzogs Bernard zu Sachsen-Weimar-Eisenach durch Nord-Amerika in den jahren 1825 und 1826*, 2 v. in 1., Weimar, 1828.

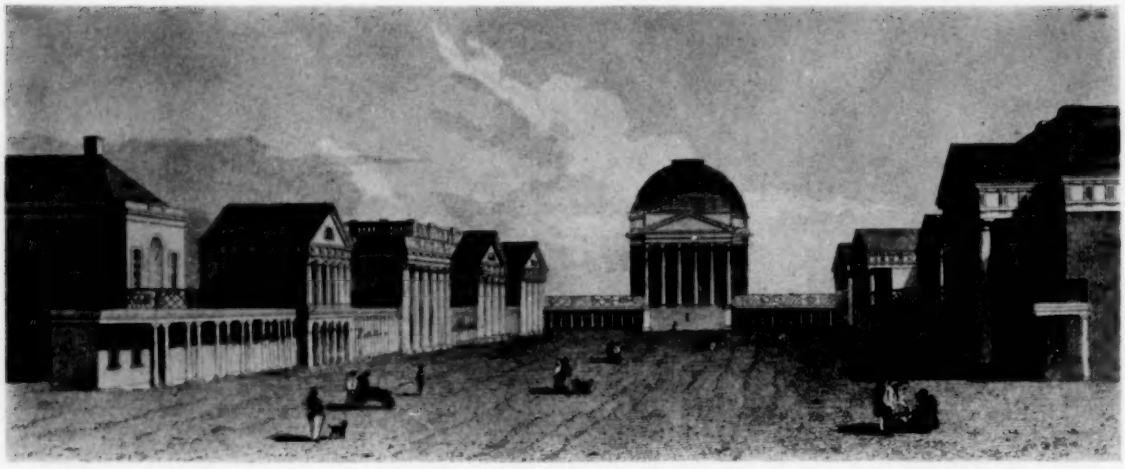


FIG. 5. The University of Virginia as drawn by William Goodacre in 1824. It was first published by John H. Hinton in London in 1831.

Although the superintending committee of the University at their meeting of November 20, 1821, had passed a resolution "to engage a good painter to draw a perspective view of the upper level of buildings," nothing had been done to carry out this resolution until the summer of 1824.

A Mr. Goodacre, an Englishman, came to Charlottesville in May of 1824 to lecture on astronomy. His son, William Goodacre, a painter, accompanied his father to Charlottesville. During his visit to the University Mr. William Goodacre made a drawing of the Lawn, and the Rotunda, the pavilions, and the dormitories facing it (fig. 5). Although the pavilions and the dormitories were practically finished and the walls of the Rotunda were up when the drawing was made, the dome to the Rotunda was only partially completed. This fact is mentioned in a letter to Mr. D. I. Swift, written on May 22, 1824,[26] in which Jeffersons remarks, "we are at this time about building a Dome to our principal edifice." Also, the Rotunda was no doubt completely surrounded with scaffolding which covered over much of the external structure. And, too, the unfinished pavilions made it necessary for the scaffolding to remain around them. This may partially account for the poor drawings and perspectives of the Rotunda and the pavilions as shown by Mr. Goodacre's picture.

Jefferson invited Mr. Goodacre to dine with him on May 14. He accepted with this note:

UNIVERSITY OF V[a] May 14– 1824 [27]

M[r] Goodacre presents his respectful compliments, and will have great pleasure in accepting the invitation to dine at Monticello this day at three o'clock.

We hear no more of the drawing until July 1 when Mr. Goodacre, who with his father had returned to New York, wrote to Jefferson concerning it.

NEW YORK, July 1st. 1824.[28]

Honoured Sir,

The return of the Rev[d] Mr. Hatch [29] to Charlottesville affords me a safe mode of presenting you with the drawing of the University of Virginia which I promised you when I had the pleasure of visiting you at Monticello. I have found some little difficulty in making the pavillions look well with a light sky and have therefore sacrificed its appearance to that of the building.

On our return to England we have some thoughts of making engravings of some of the principal buildings in the United States. The University will be one and I should feel extremely obliged by any remarks from yourself or friends on the enclosed drawing, which will lend to improve a second.

My father presents his respects and regrets that the rapidity of Mr. Hatch's movements prevents him from writing

I am, Sir,
Yours respectfully
W[m] GOODACRE.

This drawing (fig. 5), which was 12 by 18 inches in size, was first published in 1831 (London) in John H. Hinton's *The History and Topog-*

[26] Ford, Worthington Chauncey, ed., *Thomas Jefferson correspondence*. Printed from the originals in the collection of William K. Bixby, Missouri Historical Society, 288, Boston, 1916.

[27] *Jefferson papers*, Massachusetts Historical Society.

[28] *Ibid.*

[29] The Reverend Frederick W. Hatch, Rector of Christ Episcopal Church, Charlottesville, Virginia.

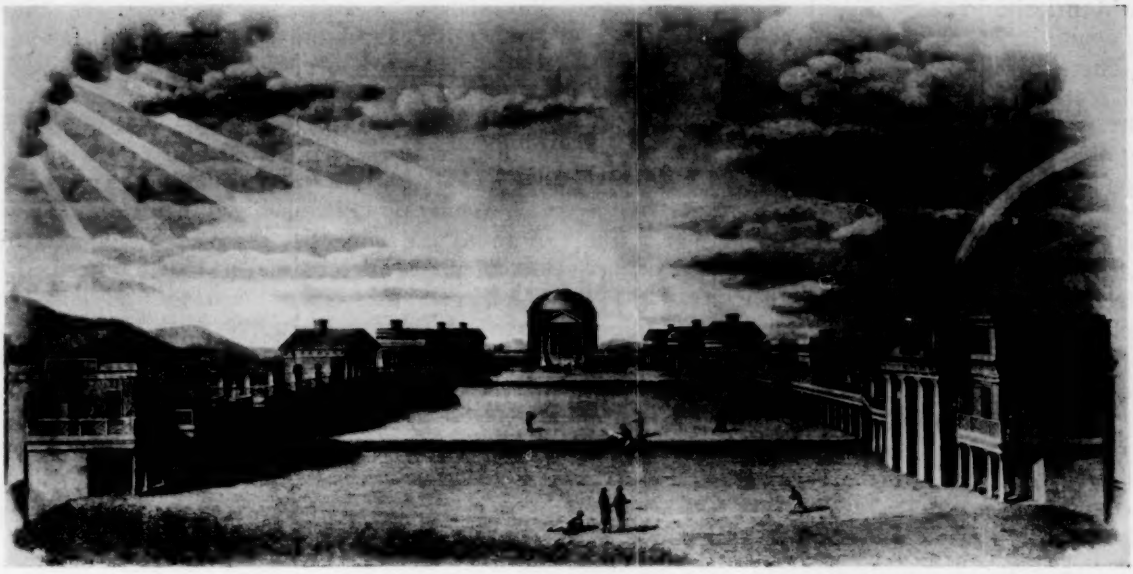


FIG. 6. The University of Virginia as drawn by a Mr. Williams in 1824. It was first published in 1826 on the map of Virginia by Böyë.

raphy of the United States of America. The print was widely distributed and was also copied with minor alterations in other publications. It is not known how Jefferson regarded the drawing. He did not live to see it engraved and finally published in Hinton's book.[30]

On September 11, 1824, Mr. Coffee became interested in making an oil painting of the University and consulted Jefferson, by letter, on the prospects of painting one.

NEW YORK Sept. 11. 1824 [31]

. . . A thought has just struck me which I cant Put aside till I have taking your good oppion, my Vanity Promps me to think that I could Paint in oil a Picture of the University as a Landscape which would make a good Picture, I ask how many Subscribers could then be hoped Supposing I succeeded in the Painting to cover the Expense of Engraving which I should think would be equal to 700 Dollars without the first Painting on impressions. Should Conjecture the Price of Plate as 10 Dollars (but this I do not know) however if there was any hopes, I do not think I should let any object to attempt such an undertaking with hopes of Proper success at the close of your Present Order.

Jefferson, in his reply to Mr. Coffee, does not appear enthusiastic over the suggestion to paint a picture of the University. His letter, however, is important because it mentions other men who had made drawings of the University.

MONT°. Sep. 19. 24.[32]

. . . I possess no data from which I could form the least conjecture what success might attend the drawing and engraving of a perspective & landscape of the university, as you propose. one has been made by a m^r^ Williams 12. by 3.1[.] which will be engraved, as a vignette, on the map of Virg^a^ now preparing for impression. another of 18. by 12.1[.] by m^r^ Goodacre, son of the gentleman of that name who lectures on astron. and is now probably in N. Y. this I understood he would engrave on his return to England. a 3^d^. of about the same size has been done by a m^r^ Cook, a drawer by profession, with a view also to engraving it for sale. one or two painters of superior order have thought of doing the same thing. this is the only information I can give you on this subject & salute you with friendly respect & esteem.

TH: J.

There is no information in the records that Mr. Coffee carried out his plan for painting a picture of the University. Probably if he had returned

[30] See letter, Jefferson to W. J. Coffee, September 19, 1824.

[31] *Jefferson papers*, The Library of Congress.

[32] *Jefferson papers*, Massachusetts Historical Society.

to Monticello in 1825, as he had expected to do, he would have consummated his plan.

There appeared in April of 1826 a new map of the state of Virginia. This map is known as the Böyë map because it was "Constructed, in conformity to *Law*, from *Surveys* authorized by the *Legislature* and other original Documents, by Herman Böyë." The engraver was H. S. Tanner. In the upper left-hand corner of the map is a large vignette of the University of Virginia (fig. 6). The original drawing, 3 by 12 inches, was made in 1824 by a Mr. Williams. Jefferson mentions this fact in his letter of September 19, 1824, to Mr. Coffee. Jefferson saw the original drawing and probably saw the printed map as it was completed three months before his death. John H. B. Latrobe, who visited the University in 1832, wrote that the vignette of the University on the recent map of Virginia is "a very accurate one." [33] In its perspective and detail of drawing it is far more accurate than the Goodacre drawing although it was drawn at approximately the same time.

In his letter of September 19, 1824, to Mr. Coffee, Jefferson mentions a third drawing by a "Mr. Cook, a drawer by profession, with a view also to engraving it for sale." This drawing was of about the same size as the one done by Mr. Goodacre. No copy of it has been identified.

Jefferson thus knew two groundplans and three drawings of the upper level of the University of Virginia: the two groundplans, known as the "Maverick Plans"; the Goodacre drawing, now commonly known as the "Hinton Print"; the Williams drawing, now known as the "Böyë Vignette"; and the unidentified Cook drawing.

[33] Semmes, John E., *John H. Latrobe and his times, 1803–1819*, 247, Baltimore, Norman, Remington, 1917.

THE ANTIQUARIES AND SIR HENRY SPELMAN

An Essay in Historiography

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I

In the year 1572 a group of Englishmen interested in what it was then customary to call "antiquities" formed a society under the patronage of Archbishop Matthew Parker for the promotion of historical study and research. In this earliest of historical societies in the English-speaking world lawyers predominated numerically, but historians, archivists, bibliographers, heralds, genealogists, and clergymen were included. Sir William Dethick, one of the original members, was a herald who later became Garter King at Arms, and his apartment in the Herald's Office came to be the society's regular place of meeting. Members presented written papers or delivered oral reports on historical subjects previously assigned to them, such as "The Antiquity of the Laws of this Island," "Of the Antiquity and Privileges of the Houses or Inns of Court, and of Chancery," "Of the Antiquity, Power, Order, State, Manner, Persons, and Proceedings of the High Court of Parliament in England," "Of the Antiquity of the Christian Religion in this Island." The written papers were deposited in the society's archives, and the substance of the oral reports was recorded by a secretary, who kept minutes of the meetings. No doubt there were animated discussions and learned wranglings, but of such no record seems to have survived. It may safely be assumed that the convivial side of scholarly intercourse was not neglected, and we may guess that there was a minimum of administration. Executive secretaries and directors were still far in the future.

The Society of Antiquaries, as it was called, contemplated the establishment of a library for the preservation of "divers old books concerning the matter of history of this realm, original charters, and monuments" and for "the better information of all noblemen and gentlemen studious of antiquity, whereby they may be enabled to do unto her majesty and the realm such service as shall be requisite for their place." Some years after the founding of the society a petition to Queen Elizabeth was drawn up asking for the incorporation of an "academy for the study of antiquity and history" to have charge of the projected library, there being, the petition stated, "divers gentlemen studious of this knowledge, and which have of a long time assembled and exercised themselves therein, out of which company and others that are desirous, the body of the said corporation may be drawn." Assurances were given that the proposed academy would not compete with or injure either of the ancient universities, since it was not to "meddle with the arts, philosophy, or other final studies there professed, for this society tendeth to the preservance of history and antiquity, of which the universities, long buried in the arts, take little care or regard."[1] This project, however, did not materialize, and the proposed library and academy were not established.

It is impossible to compile a complete list of the members of the Society of Antiquaries,[2] but the society was undoubtedly representative of the best historical talent that Elizabethan England had to offer. Among its members were: Arthur Agarde, described as *antiquariorum insignis*, an official in the Exchequer and an enthusiastic cataloguer of musty treasury records and diplomatic documents; the learned divine Lancelot Andrewes, chaplain to Queen Elizabeth and afterwards Dean of Westminster, Bishop of Chichester, Bishop of Ely, a member of the Privy Council and a staunch defender of the royal prerogative in the reign of James I; William Camden, foremost among the anti-

[1] In 1622 Camden endowed a lectureship in history at Oxford. This was the origin of the present Camden Professorship of Ancient History, the oldest academic chair of history in England.

[2] Thomas Hearne, writing in the early eighteenth century, was unable to give a complete list of members, "several of their names having been industriously concealed since the dissolution of the society." *A collection of curious discourses* (see note 4, below), I: "Mr. Hearne's Preface to the Former Edition," lvii. A list of members given in *ibid.* II: 421–449, numbers thirty-six, but it is not complete.

quaries of his day, author of the celebrated *Britannia* which has been called the most important historical work by an English author since Matthew Paris in the thirteenth century; Sir Robert Cotton, friend of Camden and lifelong collector of manuscripts and records, founder of the great Cottonian Library which later became one of the basic collections in the Library of the British Museum, a member of Parliament and friend of parliamentary leaders in the early Stuart period; Sir John Davies, a learned lawyer and author, educated at Oxford and the Middle Temple, Solicitor General and Attorney General of Ireland and Speaker of the Irish House of Commons under James I; Sir John Dodderidge, also trained at Oxford and the Middle Temple, serjeant at law and prolific writer, esteemed as one of the ablest members of the society, a judge of the Court of King's Bench under James I and Charles I; William Hakewill, a product of Oxford and Lincoln's Inn, a parliamentarian of the early Stuart period and author of a tract on parliamentary procedure that became famous; Michael Heneage, keeper of the records in the Tower of London; William Lambarde, author of important works in English legal history and editor of the first published collection of the laws of the Anglo-Saxon kings; Sir Walter Raleigh, most versatile of Elizabethans, whose multifarious public activities in England's most adventurous age were combined with an eager interest in all phases of its intellectual life; Sir Henry Spelman, who devoted his later years to the collection of historical materials and the writing of treatises of great originality and importance in the fields of English legal and ecclesiastical history; John Stow, a tireless collector of materials on English history, author of a summary of English chronicles that went through several editions in his lifetime, and remembered by later generations for his *General Chronicle of England* and his *Survey of London*.

The society continued through the remainder of Elizabeth's reign. Her successor, however, was less well disposed toward it than she had been. James I appears to have been suspicious of the tendency of antiquarian research into matters of state and church; perhaps a sound intuition told him that "ardent searchers of moldering records," to borrow Maitland's happy phrase, were a potential menace to Divine Right monarchy. At the time of his accession to the throne of England, moreover, the society had lost powerful supporters. Its original patron, Matthew Parker, Elizabeth's first Archbishop of Canterbury, had died a few years after it was established, and John Whitgift, her last Archbishop and also a friend of the Antiquaries, died in the first year of the new reign. Thomas Hearne, the celebrated eighteenth-century antiquary, says that the society had influential enemies who alleged that some of its members were disaffected to the Established Church and gives us to understand that it was looked upon as prejudicial to "certain great and learned bodies." At any rate, its meetings were discontinued early in the reign of James I.

About ten years later, in 1614, according to Sir Henry Spelman, an attempt was made to revive the society. A meeting was held at which Camden, Cotton, Davies, Hakewill, and Spelman were present, and it was agreed that "for avoiding Offence" members should "neither meddle with Matters of State, nor of Religion." But before the next meeting, Spelman says: "we had notice that his Majesty took a little Mislike of our Society; not being inform'd that we had resolv'd to decline all Matters of State. Yet hereupon we forbare to meet again, and so all our Labours lost." Thus the society came to an end. The present English Society of Antiquaries, which originated in the early eighteenth century and received a royal charter in 1751, has no connection with the Elizabethan society despite the identity of the names.[3]

The society's records and papers were dispersed, but many of them found their way into Sir Robert Cotton's library. Copies of some of the papers presented at the meetings eventually came into the hands of Hearne who published them in 1720 in an octavo volume entitled *A Collection of Curious Discourses written by Eminent Antiquaries upon several Heads in our English Antiquities*. In his preface Hearne praised these discourses as containing "abundance of excellent learning throughout, which will be the more entertaining upon account of the brevity made use of by the respective authors," men, he called them, "of a deep reach" who "had studied our antiquities with the utmost care and diligence."[4]

[3] For the origin of the later society, see *Archaeologia* 1: xxii ff., 1773 and David C. Douglas, *English scholars*, 130 ff., London, Jonathan Cape, 1939.

[4] The foregoing account of the Society of Antiquaries is based upon the following: A prefatory statement to Sir Henry Spelman's *The original of the four terms of the year*, published in *The posthumous works of Sir Henry Spelman Kt. relating to the laws and antiquities of England;* this forms the second part of *The English works of Sir Henry*

II

The Society of Antiquaries was an institutional expression of the eager interest in English history that was an element in the culture of sixteenth-century England, an interest that owed something to royal patronage, something to the New Learning with its widening of mental horizons, and much to the Reformation and national patriotism. It has been well said that "devotion to England, devotion to the king, and devotion to the church combined to produce a zeal for antiquarian study such as had never fired English scholarship before."[5] Intelligent kings have always been aware of the important service that history, discreetly presented and interpreted of course, could render to their fame, their dynasties, and their policies. It would be naïve to suppose that Henry VIII was actuated by purely disinterested historical curiosity when he appointed John Leland as King's Antiquary in 1533, the year in which he bade final defiance to the Pope by marrying Anne Boleyn.[6]

The Reformation, in England as elsewhere, stimulated historical investigation. Reform movements that antedated the advent of the modern idea of progress have in general appealed to the past, and the Reformation was no exception. Reformers have shown an inveterate tendency to gaze wistfully, and with myopic vision, at golden ages in which, it has seemed to them, they have seen as actually existing the conditions they desired to bring about. They, as well as their conservative opponents, have looked backward—usually much farther backward—and no reformation could hope to make headway unless it seemed to be a restoration. Nothing was more damaging to an opinion or a policy than the belief that it was something new under the sun. The reformer's attitude toward novelty was neatly expressed in a famous resolution passed by the Puritan majority in the House of Commons in 1629, on the eve of the Puritan Revolution:

> Whosoever shall bring in innovation of religion, or by favor or countenance seek to extend or introduce Popery or Arminianism, or other opinion disagreeing from the true and orthodox church, shall be reputed a capital enemy to this kingdom and commonwealth.

What was true of reformers in the seventeenth century was equally true of them in earlier centuries. They must place the stigma of innovation on their opponents. Protestant reformers of the sixteenth century could not argue in favor of the repudiation of papal authority and at the same time admit that it had been validly exercised for centuries. It must be shown to have been a usurped authority which did not exist in the good old days, and to that end there had to be recourse to history as well as to Scripture, both interpreted so that the "truth" would appear. The preamble of one of Henry VIII's ecclesiastical statutes appealed to "divers sundry old authentic histories and chronicles" (without naming them) as showing that England in the olden time had not been subject to any external authority, spiritual or temporal. It is not difficult to understand why champions of the English Reformation believed that a reform in historiography, as well as in theology and ecclesiastical administration, was urgently called for. English history must be revised and cleansed of all Romish coloring and bias.

The first important monument of sixteenth-century English historiography, however, was the work not of an Englishman but of an Italian. Polydore Vergil, sent to England by Pope Alexander VI as a sub-collector of Peter's Pence, found favor at the court of Henry VII and was asked by that monarch to write a history of England. His work (*Historiae Anglicae Libri XXVI*), the fruit of many years' research in medieval chronicles, statutes, diplomatic documents, and other sources, of wide reading in contemporary literature, of conversations and correspondence with learned friends, and of personal observation, was dedicated to Henry VIII

Spelman Kt. . . . by Edmund [Gibson] *Lord Bishop of London* (London, 1723; 2nd ed., 1727). *A collection of curious discourses written by eminent antiquaries . . .* (two-volume edition, London, 1775), I: Introduction and "Mr. Hearne's Preface to the Former Edition," II: "A Project touching a Petition to be exhibited unto her Majesty for the Erecting of a Library and an Academy for the Study of Antiquities and History" and "A List of Such Persons who appear to have been Members of the Society of Antiquaries in the Reign of Queen Elizabeth." *Archaeologia* 1: i ff., 1773.

[5] McCusker, Honor *John Bale: dramatist and antiquary*, xi, Bryn Mawr, 1942.

[6] It has generally been stated that Leland was given the title of "King's Antiquary." Lucy Toulmin Smith, the editor of *The itinerary of John Leland* (5 v., London, G. Bell and Sons, 1907–1910), points out, however, that Leland, who signed himself "Antiquarius," did not claim this title, and she doubts whether it was actually given to him. *Ibid.*, I: ix, n. 3. More recent writers, nevertheless, have continued so to style him, e. g., Honor McCusker, *John Bale*, 55.

and published in 1534. The thoroughness of Polydore's investigations, considering the materials that were available to him, and the elegance of his Latin narrative no doubt justify the high praise that modern scholars have given to his work. It exhibits a critical spirit in the handling of historical authorities and an independence of judgment remarkable for the age in which it was written. For example, Polydore, applying historical criticism to the fantastic fables and fabrications of Geoffrey of Monmouth, which for centuries had been circulating as historical truth, rejected the time-honored legend that Brutus, great-grandson of Aeneas, was the founder of Britain and gave his name to the land.

The general acceptance of this tale is a good illustration of the prevalent historical credulity, and even a Trojan origin of Britain was not ancient enough to suit all tastes. The era of the Flood was more satisfying to some eminent historians as the formative period of British history. One of the savants of the Society of Antiquaries, Joseph Holland, presented a marvellous macedoine of myths, though he made it clear that he personally did not vouch for its historicity:

> Forasmuch as it resteth uncertain, when and by whom this island was first inhabited, and that our authors do vary therein, I will begin with the most common received opinion, which is that Samothes the sixth son of Japheth, one of the sons of Noah, was the original beginner. He came into this land about 52 years after the flood, and he called it *Samothea*, in which name it continued until Albion the son of Neptune, who descended of Cham, entered the same, and changed the name of *Samothea* into *Albion*. Some authors do affirm that it was called Albion *ab albis rupibus*, of the white chalky cliffs in the east and south parts of this land; some others will have it come of the Greek word *olbion*, which signifieth *felix*, a happy country to dwell in; some of Albina, Dioclesian's daughter, which is held to be fabulous. It continued in the name of Albion 608 years, until Brute's arrival here, who conquered this land, and changed the name thereof from Albion into Bretayn or Brutayn, which name hath been diversly expounded, according unto sundry mens opinions and expositions, as Britania, Brutania, Bridania, Pritania . . . and divers others; but were it not that the name of Brute is rejected by divers men of good judgment, I could be persuaded that it might most truly be called Brutayn of Brute. But forasmuch as in the histories of Italy there is a large pedigree set down wherein they derive themselves from the Trojans and from Aeneas, setting down his genealogy both for Italy and France, but make no mention of Brute, and that some of the authors do say, that *totus processus de Bruto illo est magis poëticus quam historicus*, for my own part, I will leave it to be decided by men of better judgment than myself.[7]

Mr. Holland's paper expressed the mythological syncretism, characteristic of the Middle Ages, which wove biblical and classical strands into what seems like a crazy quilt to the modern mind. The writer was a genealogist, as might be inferred from internal evidence.

If we consult the great Camden on this vexed question of British origins, we shall be less inclined to censure Mr. Holland for exceptional credulity. In his *Britannia* Camden remarks that the truth regarding the original inhabitants of Britain and the derivation of the name is "sunk in the revolutions of so many ages" and observes that there have been persons who, "not being able to relate the truth, endeavored at least to amuse their readers by inventing stories, dressed up with an agreeable variety, and founded on certain opinions of their own about the origin and names of nations." He then goes on to summarize Geoffrey of Monmouth's story of Brutus. All this sounds familiarly modern and critical. Yet Camden declines to reject the story. "For myself, I am so far from attempting to overthrow that tale, that I have frequently exerted my utmost to support it; to slight it, would be to war against Time, and combatting a received and common opinion." So he refers the whole question to the Society of Antiquaries. He presents the arguments which skeptics have brought against the story and recognizes their force, but he evidently thinks that it serves a useful patriotic purpose, and this seems to be his chief reason for not rejecting it flatly. "For myself, let Brutus be accounted the father and founder of the British nation, I shall not contradict it; and let the Britons lay claim to Trojan origin. . . . I shall not go about to disprove it. . . . We must allow antiquity to combine truth and falsehood, things human and divine, in order to make the origin of nations and cities more illustrious and august. . . ." At the same time Camden expresses his extreme devotion to truth! And in the name of truth he offers a conjecture which he considers more plausible than the Brutus story. According to this, the ancient Britons derived their origin and the name they called themselves, Cymero

[7] *A collection of curious discourses* I: 93–94.

or Cumri, from the Gauls, who were formerly called Gomari or Gomeri from Gomer, eldest son of Japheth, son of Noah.

> From these *Gomari, or Gomeri*, of Gaul, I always supposed our Britons derived both their origin and their name, which is a proof of their origin; and the proper and peculiar name of the Britons confirms this. For they call themselves *Kumero, Cymero*, and *Kumeri*. . . . Nobody denies that the *Thracians, Ionians, Riphæans, Muscovites*, & c. are descended from Thiraz, Javan, Riphat, and Moschi, or Mesech, because the names agree. All allow the *Ethiopians* also to spring from Cush, and the *Egyptians* from Misraim, sons of Ham, because they go by the same names in their own language. Why then should we not allow, that our Britons, or Cumri, are the very descendants of Gomer and called after his name . . .? And this origin from Gomer and Gaul seems more interesting, antient, and better founded than that from Brutus and Troy.[8]

It would seem, then, that even if Camden had definitely rejected the Brutus story it would not have been because that tale put too heavy a strain on his credulity. We must frankly recognize that men whom their contemporaries regarded as erudite and trustworthy historians were credulous to a degree that it is difficult for us to understand—that we can understand only in the light of an historical-mindedness generated by sympathetic immersion in the thought of their age—when they attempted to peer into the far and misty past.

Milton, writing a generation later, retails the Brutus legend and other fables recounted by Geoffrey of Monmouth, but he was definitely skeptical: In his *History of Britain* he says:

> Thus far, though leaning only on the credit of Geffrey Monmouth, and his assertors, I yet for the specify'd causes have thought it not beneath my purpose to relate what I found. Whereto I neither oblige the belief of other persons, nor over-hastily subscribe mine own. Nor have I stood with others computing, or collating, years and Chronologies, lest I should be vainly curious about the time and circumstance of things whereof the substance is so much in doubt.[9]

Milton believed that the authentic history of Britain began with Julius Caesar.

But to return to Polydore, it is not strange that he was attacked by patriotic English antiquaries. John Bale accused him of having corrupted English history with "Romish lies and other Italish beggarys," Leland came to the defense of Geoffrey of Monmouth with a tract "contra Polydorum Vergilium," and Sir Henry Savile, an Elizabethan antiquary, attacked Polydore on the ground that, being a foreigner and not well versed in English affairs, he was unreliable.[10]

Pre-Elizabethan Tudor antiquarianism is exemplified in the work of Bale and Leland. Both men were enthusiastic bibliophiles, compilers, and collectors of historical materials, and both were partisans of the Reformation. Bale may fairly be called a violent partisan who did not hesitate to express his anti-Catholic sentiments in language that was strong even for his day. When he turned his attention to monks and popes, as he often did, vituperation reached a new high, though Froude's cavalier characterization of him as a "foul-mouthed ruffian" falls short of suggesting his importance in the history of English literature and historiography. Bale was a dramatist as well as an antiquary, and it is in the former role that he is known today to students of the history of English literature.[11] Bale's historical activities began in his pre-Protestant days when, as a Carmelite monk, he became deeply interested in the history of his order. He was a student at Cambridge in the second and third decades of the sixteenth century, when the ideas of Cranmer, Latimer, and other religious reformers were afloat there, and the seeds of revolt may well have been planted in his mind then, though he afterwards held the office of prior in two or three Carmelite convents. It seems to have been in 1533 that he withdrew from monastic life and became a secular clergyman.

It was in that same year that Leland, keeper of the King's libraries, was commissioned by Henry VIII to search the libraries of the mon-

[8] For Camden's discussion, see Richard Gough, *Britannia: or, a chorographical description of the flourishing kingdoms of England, Scotland, and Ireland and the islands adjacent, from the earliest antiquity. By William Camden. Translated from the edition published by the author in MDCVII. Enlarged by the latest Discoveries* I: li ff., 2nd ed., folio, London, 1806.

[9] *The works of John Milton*, ed. by John Mitford, V: 27, London, 1851.

[10] *Select works of John Bale*, ed. for the Parker Society by Henry Christmas, 8, Cambridge, 1849. *Three books of Polydore Vergil's English History*, ed. for the Camden Society by Sir Henry Ellis, xx-xxiii, London, 1844.

[11] Recent studies of Bale are Jesse W. Harris, *John Bale: A study in the minor literature of the Reformation*, Univ. of Ill. Press, 1940, and Honor McCusker, *John Bale: Dramatist and antiquary*, Bryn Mawr, 1942.

asteries and colleges of England, "to the intent," as Leland wrote in a report which he presented to the King some years later, "that the monuments of ancient writers, as well of other nations as of this your own province, might be brought out of deadly darkness to lively light."[12] Leland formed ambitious historiographical plans, including the writing of a history of England and Wales, county by county, but they did not materialize. His extensive manuscript collections and compilations were scattered, though a good deal of his work was known to Camden and other antiquaries in the sixteenth and seventeenth centuries. Hearne published his *Itinerary* in a nine-volume edition in 1710–1712 and brought out a considerable body of his papers in a six-volume collection, cited as Leland's *Collectanea*.

Just when Leland and Bale first became acquainted is not known, but they were in correspondence at least as early as 1536, when Bale wrote to Leland praising his work and offering assistance. Both men, though they were strongly in favor of Henry VIII's new deal, deplored the dispersal and destruction of manuscripts that followed the dissolution of the monasteries. Leland tried to interest Thomas Cromwell in the salvaging of manuscripts,[13] and Bale left on record his grief and indignation at the fate that befell so much of the contents of the monastic libraries:

> I dolorously lament so great an oversight in the most lawful overthrow of the sodometrous Abbeys and Frieries, when the most worthy monuments of this realm so miserably perished in the spoil . . . . to destroy all without consideration is and will be unto England for ever a most horrible infamy. . . . A great number of them which purchased those superstitious mansions reserved of those library books, some to serve their jakes, some to scour their candlesticks, and some to rub their boots. Some they sold to the grossers and soap sellers, & some they sent over sea to the bookbinders, not in small number, but at times whole ships full. . . . But cursed is that belly which seeketh to be fed with such ungodly gains and so deeply shameth his natural country.[14]

Like Leland, Bale was a great collector of books and manuscripts, and he built up one of the largest English libraries of his day. These two men were probably more responsible than any others for preserving manuscripts that would otherwise have perished. After Bale's death most of his collections were acquired by Archbishop Parker, and the bulk of Parker's manuscripts came to rest in the library of his Cambridge college, Corpus Christi.

There can be no doubt that Bale, again like Leland, had great influence on English historiography. Two extensive catalogues which he complied were published during his lifetime and became the common property of antiquaries. They were entitled, respectively, *Illustrium Maioris Britanniae Scriptorum . . . Summarium* and *Scriptorum Illustrium Maioris Britanniae . . . Catalogus*. The former, published at Basle in 1548, has been called the first detailed history of English literature.[15] In form these catalogues resemble what we would call biographical dictionaries. Bale was one of the first to call for a revision of the English chronicles along patriotic and Protestant lines. Polydore Vergil, he said, had been "too familiar with the bishops, and took too much of their counsel, when he compiled . . . his English history," and he had given the impression that England had been almost barren of learned men.

> I would wish some learned Englishman (as there are now most excellent fresh wits) to set forth the English Chronicles in their right shape. . . . I cannot think a more necessary thing to be labored to the honor of God, beauty of the realm, erudition of the people, and commodity of other lands, next the sacred scriptures of the Bible, than that work would be. For truly in those they have there yet is vice more advanced than virtue, and Romish blasphemy than godliness.[16]

One chapter of medieval English history that evidently needed to be revised was the long cherished story of Thomas Becket—St. Thomas of Canterbury—to whose shrine pilgrims had been repairing for centuries, a story in which Henry II cut so sorry a figure. From the point of

[12] *The laboriouse journey and serche of Johan Leylande for Englandes antiquities* in *The itinerary of John Leland*, ed. by Lucy Toulmin Smith, I: xxxvii–viii, London, G. Bell and Sons, 1907. The record of Leland's tours, which occupied his time for several years, is set down in his *Itinerary*, which contains a wealth of information on the topography, antiquities, and conditions then existing in the localities he visited. It was first published by Thomas Hearne.

[13] *The lives of those eminent antiquaries John Leland, Thomas Hearne, and Anthony à Wood* I: 12, Oxford, 1772.

[14] From the dedication and preface to Bale's annotated edition of Leland's *Laboriouse journey*, in *The lives of those eminent antiquaries* I, cited above.

[15] Harris, Jesse W., *John Bale*, 127.

[16] *Select works of John Bale*, 8.

view of the Reformation, kings should be praised on general principles and medieval saints deposed from the niches to which tradition had assigned them. To this congenial task Bale addressed himself in one of his numerous plays, *Impostures of Thomas à Becket*. This is not extant, but its spirit can presumably be inferred from its title. Another of his plays, which has survived, is *King John*, in which the Angevin monarch is glorified as a patriot king and precursor of Henry VIII in the latter's conflict with the papacy.[17] This was intermediate in character between the old morality plays and Shakespeare's historical dramas. King John appears in his own name, but the *dramatis personae* include a number of allegorical characters, among them Sedition, Usurped Power, Dissimulation, Treason, Imperial Majesty, and Verity. The comparison of John with Henry VIII was not left to the discernment of the audience. It was made explicit by the Interpreter at the end of the first act:

In this present act we have to you declared,
As in a mirror, the beginning of King John,
How he was of God a magistrate appointed
To the governance of this same noble region,
To see maintained the true faith and religion;
But Satan the Devil, which that time was at large,
Had so great a sway that he could it not discharge.
. . . . . .
This noble King John, as a faithful Moses,
Withstood proud Pharaoh for his poor Israel,
Minding to bring it out of the land of darkness,
But the Egyptians did against him so rebel,
That his poor people did still in the desert dwell,
Till that duke Josuah, which was our late King Henry,
Clearly brought us into the land of milk and honey.
As a strong David, at the voice of verity,
Great Goliah, the pope, he struck down with his sling,
Restoring again to a Christian liberty
His land and people, like a most victorious King;
To her first beauty intending the Church to bring,
From ceremonies dead to the living word of the Lord.

Bale's historical point of view and interpretation became dominant in English historiography and remained so till the advent of a fairer and more judicious historical spirit.

[17] This has been edited, with the title *Kynge Johan: A play in two parts, by John Bale*, for the Camden Society and published in 1838. A more recent edition is by John Henry Pyle Pafford, based on a manuscript in the Huntington Library and printed for the Malone Society by the Oxford University Press in 1931.

Matthew Parker was a contemporary of Bale and Leland, but he lived till 1575, surviving Bale by twelve years and Leland by nearly twenty-five and thus qualifying as an early Elizabethan. Though he held the highest office in the Church of England at a formative period in the church's history, he can hardly be regarded as a great divine or theologian. He was a moderate man, temperamentally averse to religious "enthusiasm" and violent controversy, and it was such a one that Elizabeth wanted as her first Archbishop of Canterbury. In matters ecclesiastical Parker's policy was one of restoration; his object, as stated in his own words, was "that that most holy and godly form of discipline which was commonly used in the primitive church might be called home again." His *De Antiquitate Ecclesiae*, printed in 1572, traced the traditions of the Church of England back to the earliest of his predecessors, St. Augustine of Canterbury.

It was in the realm of scholarship that Parker achieved his true eminence, and it was from scholarly pursuits, to which he remained addicted throughout his life, that he derived his principal satisfactions. He was a deep student of patristic literature from his early days, and he became versed in Anglo-Saxon antiquities and strove to revive the study of the Anglo-Saxon language. Antiquarian scholarship was the solace of his declining years. In the words of John Strype, his principal biographer:

> The spare Hours of his old Age . . . he spent in searching into ancient Authors, then not come to light, and in comparing the Opinions of the modern Doctors with the Opinions of the Ancients. And especially he enquired into our British and Saxon Monuments, which treated of this Church of Britain. Whereby he saw evidently how much this our Church, by the Encroachments of the Papacy, had deviated from its ancient Doctrines and Practices.[18]

"A mighty Collector of Books," Strype rightly called him, and "one of the greatest Antiquaries of the Age." The Parker Manuscripts at Corpus Christi College, Cambridge, form one of England's famous collections today. As a collector, Parker carried on in the tradition of Bale and Leland, and he had the advantage of a long purse. He employed agents to search for and copy manuscripts both at home and abroad, and when archbishop he maintained a staff of trans-

[18] Strype, John, *The life and acts of Matthew Parker*, 508, London, 1711.

cribers, illustrators, and binders at Lambeth Palace The printing of a number of medieval chronicles was one result of his work in collecting manuscripts. "For the better Communication and Encrease of this Antique Learning," says Strype, "our Archbishop kept a Correspondence with several great Antiquaries," and, as noted above, he was the patron of the Society of Antiquaries.[19]

III

Generally speaking, the antiquaries were not historically minded in our meaning of that term. They flourished before the rise of the modern historical sense, before evolutionary ideas came to color men's thought about the past, before the advent of anthropology with its teachings regarding primitive peoples. The discovery of the antiquity of man lay far in the future. Biblical chronology still held universal sway, and it was supposed that the Creation, the Flood, and all other events important in human annals could be accurately dated. The most celebrated effort along this line was made by the learned theologian and antiquary James Ussher, Archbishop of Armagh and Primate of the Church of Ireland, a friend of Camden, Cotton, and other eminent antiquaries. Selden called him "learned to a miracle"—*ad miraculum doctus*. In his *Annales Veteris et Novi Testamenti* he assigned precise dates to biblical events from the Creation to the Destruction of the Temple at Jerusalem. He fixed the Creation at the beginning of the night which preceded the twenty-third of October, 4004 B.C.

The antiquaries were naïvely present-minded, though not in the sense of being obsessed, like so many historical writers today, with a belief in the intrinsic superiority of their own times to all times preceding. On the contrary, the golden age was still in the past. Science and technology had not yet given rise to the spirit of secular optimism, the vision of indefinite improvement in the conditions of human life, the idea of progress. For the souls of the faithful and godly there was, of course, a future state of ineffable and eternal bliss, but that is another story. The antiquaries lived in the infancy of modern historical scholarship, and their outlook upon the past was naturally present-minded, for present-mindedness is men's natural attitude toward the past. Historical-mindedness is a fair—and, it is to be feared, a rare—flower of culture, a product of the scientific spirit applied to historical study. "It is scarcely an exaggeration to say," Professor G. N. Clark observes, "that the sixteenth-century writers [of history] had no idea of change, no idea that one age was different from another. . . . The Renaissance historians did not know that men and events are made what they are by the character of the age to which they belong."[20] Theater-goers in Shakespeare's day were not conscious of incongruity when ancient Romans or ancient Britons appeared on the stage in Elizabethan garb, for they thought of the characters in the play as people just like themselves. Today a theatrical producer may decide to present *Hamlet* in twentieth-century costume, but if the Prince of Denmark appears in a dinner jacket, the audience understands that this is an anachronistic stunt. The antiquaries had little if any sense of time-depth, of the cultural and psychological differences between men of the olden times and themselves, and they were therefore pre-disposed to what Maitland called the besetting sin of English legal tradition—"antedating the emergence of modern ideas."

Many instances of this could be given from the papers presented in the Society of Antiquaries and printed in Hearne's *Collection of Curious Discourses*, but two examples must suffice for purposes of illustration.

A good instance of historical misunderstanding caused by reading present ideas into the past occurs in a paper on *Camera Stellata* presented by Mr. Tate, in which he took the term *judicium parium* (judgment of peers) of Magna Carta to have meant *at the time of Magna Carta* what it had come to mean in his day. After quoting the famous *Nullus liber homo* chapter of Magna Carta, he said:

> Hereby the common subject thought himself freed from that absolute authority which the former kings and their council of state had exercised upon him, and that he ought not from thenceforth to be drawn to answer in any cause, except it were by way of indictment, or presentment of good and lawful men, being his peers, or by process made upon writ original, after the way of law.

Mr. Tate interpreted *judicium parium* as having meant *in 1215* indictment or presentment by a grand jury, though at that time this well-known term of feudal jurisprudence never referred to

[19] For an account of Parker's achievements as an antiquary, see Section II of the "Observations" appended to Strype's *Life*.

[20] *The seventeenth century*, 273, Oxford Univ. Press, 1929.

action by a jury. Mr Tate should not be held up to ridicule for this anachronism. That "the judgment of peers" of Magna Carta meant, and had always meant, a verdict or indictment of a jury was held by the legal profession generally in his day and for generations afterwards. It became one of the most cherished beliefs in the tradition of English liberty, and it still lingers on.

In a group of papers on Parliament is one by Sir John Dodderidge in which he began with assemblies and councils among the ancient Britons and continued through the Roman and Anglo-Saxon periods. Where factual information is scanty large scope is given to ingenious conjecture, and it was quite clear to Sir John that King Canute held a Parliament, "though not then so called," he admitted, "but yet truly so to be accounted: and since that it hath all the parts of our parliament, we might rightly call it so." He was not content, however, with an origin as recent as the reign of Canute, and in summing up he said: "So by looking back, it is easy to see the great antiquity of this high court, delivered as you see, from before the Romans."[21]

This belief in the great antiquity of Parliament was a powerful aid to the parliamentarians in their conflicts with James I and Charles I over parliamentary privileges. In their search for precedents with which to combat the claims of the Crown the parliamentary opposition leaned heavily upon the Antiquaries, several of whom were themselves members of Parliament. We read of a meeting—a sort of caucus—of leading members of the House of Commons held at the home of Sir Robert Cotton on the eve of the momentous session in which the Petition of Right was passed.[22] Sir Edward Coke is a conspicuous example of an antiquary who knew how to impress history—or what passed with him as such—into the service of present politics. Coke is best remembered as "the oracle of the law," the great authority on whose *Reports* and *Institutes* generations of lawyers were brought up. But he was also a member of Parliament in his later years and one of the authors of the Petition of Right. He does not seem to have been a member of the Society of Antiquaries, but he was undoubtedly on familiar terms with several of its members. He was convinced of the great antiquity of Parliament, the law courts, and the common law, and he seized eagerly on any authorities that appeared to support his views. "When he was on unfamiliar ground," Maitland remarked, "Sir Edward Coke was, of all mankind, the most credulous. There was no fable, no forgery, that he would not endorse; and a good many medieval legends and medieval lies passed into currency with his name upon their backs."[23] In some way Coke came by a manuscript copy of what purported to be a medieval law book, *The Mirror of Justices*, which he devoured with what Maitland called his habitual "uncritical voracity" and pronounced to be "a very ancient and learned Treatise of the Laws and Usages of this Kingdom, whereby this Realm was governed about 1100 years past." On the basis of internal evidence Maitland reached the conclusion that the *Mirror* was probably written during the reign of Edward I, and he conjectured that it was a fanciful skit, "blended of truth and falsehood, in which Bracton's staid jurisprudence" was "mingled with freaks and crotchets and myths and marvels, and decorated with queer tags of out-of-the-way learning picked up in consistories."[24] Coke, however, took it all with deadly seriousness and used it in his *Institutes* as an impeccable source of historical information. It does not seem to have been a success in its own day or generally in the Middle Ages, but thanks to Coke it was regarded as a great authority from his time to the nineteenth century. It was first printed in 1642, a few years after Coke's death.

In the Preface to the Ninth Part of his *Reports* Coke solemnly states that

> this grave and learned Author will show us in this Mirror the great Antiquity of the said Courts of the Common Law, and particularly of the high Court of Parliament ever since the time of King Arthur, who reigned about the year of our Lord 516, not that this court and the rest were instituted then, but that the reach of his Treatise extendeth no higher than to write of the Laws and Usages of this Realm continued since the reign of that King.

For Coke, and for most of the lawyers of his day, Parliament, like the Common Law, was of immemorial antiquity. In an often-quoted dictum in his *Fourth Institute* Coke used a trinity of

[21] *A collection of curious discourses* I: 285–286, 289.

[22] Gardiner, Samuel R., *History of England from the accession of James I to the outbreak of the Civil War* VI: 230–231, new ed., London, 1896.

[23] *The collected papers of Frederic William Maitland*, ed. by H. A. L. Fisher, III: 453, Cambridge, 1911.

[24] Maitland's introduction to the Selden Society's edition of *The mirror of justices* (London, 1895) is a good example of his historical learning (lightly worn), historical-mindedness, critical acumen, and characteristic gaiety of spirit.

superlatives in characterizing Parliament, and the first of these was "most ancient." *Si antiquitatem spectes, est vetustissima; si dignitatem, est honoratissima; si jurisdictionem, est capacissima.* Coke went to history not because he was interested in finding out about the past. He was first and foremost a lawyer, and he went to it in search of precedents with which to win his case. The legal historian must constantly be reminded that good law often kept company with rather disreputable history.

The theory of the extreme antiquity of Parliament did not, it is true, pass entirely unchallenged in the days of the Antiquaries, but it was none too safe to question it publicly. One Arthur Hall, a member of the House of Commons in several of Elizabeth's Parliaments, wrote a book which he caused to be printed, in which he denied the immemorial antiquity of Parliament. He saw no evidence of the existence of Parliaments before the twentieth year of the reign of Henry III—1235—"unless you will have all consultations Parliaments." He showed a (to us) refreshing degree of historical-mindedness when he remarked that ordinances were made in Anglo-Saxon times, "but how far from the way of our Parliament your own discretion will conceive, if you have good consideration of the times, people, and manner of lawing." Speaking of Canute, he said:

> Canutus the Dane . . . was absolute king of the whole Realm . . . his laws you have: see what you find there. So great conquerors do not commonly grant such large freedoms to subjects, to have interest with them in the common wealth, neither yet do bind themselves to so hard terms, to establish nothing without the consent of the other two states [lords and commons].[25]

There were other things in the book that were probably even more offensive to the Commons than the aspersions cast upon the antiquity of the House, and Mr. Hall seems to have made himself personally obnoxious to many of its members. But questioning the antiquity of the House was in itself an offense. According to D'Ewes's *Journals* of the Parliaments of Elizabeth, the House of Commons was informed that Mr. Hall had published a book tending to the slander of "sundry particular members," which contained "a long discourse tending to the diminishment of the ancient authority of this House."[26] By order of the House Mr. Hall was expelled, committed to the Tower for six months, and fined five hundred marks, and his book was adjudged to be "utterly false and erroneous." This was in 1581.

IV

There was one member of the Society of Antiquaries whose historical point of view is worthy, it seems to me, of particular notice, though not because it was typical of the Antiquaries in general. On the contrary, Sir Henry Spelman, whose important historical work was done in his later life, after the society had come to an end, was ahead of his time in his perception of the differences between past and present, and he explicitly criticized the prevailing present-mindedness in historical writing. I think he has a message for historians today.

There is no satisfactory biography of Spelman.[27] Professor F. M. Powicke has voiced a doubt whether an adequate one could be written by anybody "who had not so far mastered the learning and intellectual interests of the age as to be able to deal alike with Spelman, Selden, Prynne, and a score of other scholars from the great Camden onwards."[28] Spelman was born in Norfolk in or about 1564 and died in 1641. After spending two years or so at Trinity College, Cambridge, he studied law at Lincoln's Inn. He was later appointed High Sheriff of Norfolk and on several occasions was sent to Ireland on public business by James I, by whom he was knighted. He became interested in antiquities in early life, and he seems to have joined the Society of Antiquaries about 1593. His name does not appear as the writer of any of the papers published in Hearne's *Collection of*

[25] *An account of a quarrel between Arthur Hall, Esq. and Melchisedech Mallerie, Gent. . . . and a letter on the origin and antiquity of parliament . . . by Arthur Hall, Esq., member for Grantham in several parliaments of Q. Elizabeth* . . . , 74 ff., London, reprinted, 1815. This is included in *Miscellanea antiqua anglicana*, London, printed for Robert Triphook, 1816.

[26] Quoted in J. R. Tanner, *Tudor constitutional documents*, 592–593, Cambridge Univ. Press, 1922.

[27] Bishop Gibson's *The English works of Sir Henry Spelman Kt.*, cited in note 4, above, contains a *Life*, probably written by Gibson, and there are a number of biographical sketches. The present essay is an outgrowth of interest in Spelman and his ideas about history that was first aroused by reading, many years ago, a quotation from one of his writings in Professor Charles H. McIlwain's *The high court of parliament*, Yale Univ. Press, 1910.

[28] "Sir Henry Spelman and the 'Concilia,'" *Proc. Brit. Acad.* **16**: 349, 1930.

Curious Discourses, but Spelman himself is authority for the statement that when the attempt was made to revive the society in 1614 the origin of the law terms was assigned to him as a subject of investigation, "about which," he says, "as being obscure and generally mistaken, I bestow'd some extraordinary pains; that coming short of others in Understanding, I might equal them if I could in Diligence." The attempt to revive the society failed, as we have seen, but some of Spelman's friends showed an interest in his paper, and he decided, "upon a Review and Augmentation [revision and enlargement in our idiom] to let it creep abroad . . . wishing it might be rectify'd by some better Judgment." Scholars as a rule did not rush into print in those days, and Spelman's *Original of the Four Terms of the Year* was not published till 1684, and then from an imperfect copy of the manuscript. It was published from the original manuscript in the Bodleian Library in *The Posthumous Works of Sir Henry Spelman Kt. relating to the Laws and Antiquities of England*, cited in note 4, above.

It was not till he was nearly fifty years of age that Spelman decided to devote himself to historical research and writing. He was not satisfied with a lawyer's knowledge of the law. Such knowledge, to quote Bishop Gibson,

> could not satisfy a Mind so curious, and a Judgment so solid, as his appears to have been in all his Writings. These inclin'd him to search into the Reasons and Foundations of the Law, which he knew were not to be learnt, but from the Customs and Histories of our Nation in elder Ages; nor these Usages to be trac'd, but by a strict Examination of the most ancient Records. In truth, it is very much to the disadvantage of the Law, that they, who by their Abilities are best qualified to improve the Knowledge of it from original Records, are so much taken up with the Business of their Profession, that they have little time to bestow upon such Enquiries. As on the other hand, Men who are born to Leisure and Estates, however inclinable they may be to the more polite Parts of Learning, do seldom care to engage in a Study, which at first sight seems to be so rough, and tedious.

Spelman's scholarship was extraordinary, considering the resources available to him. Early in the course of his researches in legal history he came to be impressed with the large number of strange and obsolete terms used in legal records, both Anglo-Saxon and Latin, and the importance of ascertaining their exact meaning. Accordingly he compiled, with great labor, a glossary, the first part of which, through the letter "L," was published in 1626 with the title *Archaeologus in modum Glossarii*. A second volume appeared posthumously in 1664. Why Spelman himself did not go further with this publication has been a subject of speculation among the learned. One conjecture was that he stopped short of the letter "M" because he had written some things under the headings "Magna Carta" and "Magnum Consilium" that might give offense. Spelman's work on English, or rather British ecclesiastical antiquites—*Concilia, Decreta, Leges, Constitutiones in re Ecclesiarum Orbis Britannici*—has generally been regarded as his magnum opus. Only the first volume, coming down to the Norman Conquest, was published during his lifetime. It was a pioneer work, the first attempt to put the early history of the churches in the British Isles on a sound documentary basis. Other antiquaries—Sir William Dugdale, a friend of Spelman, and David Wilkins, who lived a hundred years later—built on the foundations Spelman had laid. Today the standard work on the subject is *Councils and Ecclesiastical Documents relating to Great Britain and Ireland: edited after Spelman and Wilkins* by Arthur West Haddan and William Stubbs (three volumes, Oxford, 1869–1878). In the preface the editors pay tribute to their predecessors:

> For the year 1737, the *Concilia* of Wilkins was a monument of gigantic labor and learning, and worthily claimed both to rival and to supplant the work, for its date equally wonderful, of Wilkins's own forerunner, Spelman.

Spelman was a deep student of English feudalism, regard being had here, of course, as always, to the materials available to him. His *The Original, Growth, Propagation, and Condition of Feuds and Tenures by Knight-Service in England*, published in 1641, the year of his death, was a work of great originality in which he showed the resemblances between English and Continental tenures. He contended that fiefs and feudal tenures, properly so called, and the feudal incidents associated with them, were not in existence in England before the Norman Conquest. "I desire to see but one Charter in the Saxon Tongue before the Conquest," he said, "wherein any *feodal Word* is apparently expressed." He had stated this view in his Glossary, but since the publication of that work it had been affirmed judicially, in an important Irish case, that

"feuds" (i. e. fiefs) originated in the Anglo-Saxon period, and in the report of the case it was stated that "Sir Henry Spelman was mistaken, who in his Glossary (verbo Feudum) refers the original of Feuds in England to the Norman Conquest." In his treatise Spelman undertook to refute this opinion of the Irish court and confirm his earlier view. It was a work of great learning, and it may be remarked that the scholarship of our own day supports Spelman. Maitland paid his respects to this treatise in a sally that must have delighted the students in his course in English constitutional history at Cambridge:

> Now were an examiner to ask who introduced the feudal system into England, one very good answer, if properly explained, would be Henry Spelman. . . . Spelman, reading continental books, saw that English law, for all its insularity, was a member of a great European family, a family between all the members of which there are strong family likenesses. This was for Englishmen a grand and a striking discovery; much that had seemed quite arbitrary in their old laws now seemed explicable.[29]

It is, however, not of Spelman the historian that we were to speak, but of Spelman the critic of historians, a man who came to perceive a major defect in the historical interpretation that was prevalent in his own day, and that is widespread today. That is why I think he has something to say to us.

In *The Original of the Four Terms of the Year*, the earliest of his historical writings though he was already fifty years of age, Spelman criticized legal historians for their lack of historical-mindedness. He concluded that treatise with these words:

> They therefore that fetch our Laws from Brutus, Mulmutius, the Druids, or any other *Brutish* or *British* Inhabitants here of old, affirming that in all the times of these several Nations, (viz. Britains [*sic*], Romans, Saxons, Danes and Normans) and of their Kings, this Realm was still ruled with the self same Customs that it is now . . . govern'd withall; do like them that made the Arcadians to be elder than the Moon, and the God Terminus to be so fixed on the Capitoline-hill, as neither Mattocks nor Spades, nor all the Power of Men nor of the other Gods, could remove him from the Place he stood in.

In the remarkable opening paragraph of a short treatise *Of the Ancient Government of England* Spelman showed his awareness of the gradualness of changes in English government and the present-mindedness with which, in age after age, its history had been viewed:

> To tell the Government of England under the Old Saxon Laws, seemeth an Utopia to us present; strange and uncouth: yet can there be no period assign'd, wherein either the frame of those Laws was abolished, or this of ours entertained; but as Day and Night creep insensibly, one upon the other, so also hath this Alteration grown upon us insensibly, every age altering something, and no age seeing more than what themselves are Actors in, nor thinking it to have been otherwise than as themselves discover it by the present. Like them of China, who never travailing [*sic*] out of their own Country, think the whole World to extend no further. As one therefore that has coasted a little further into former times, I will offer unto you a rude Mapp thereof; not like those of the exquisite Cosmographers of our latter ages, but like them of old, when as [*sic*] neither Cross Sails nor Compass were yet known to Navigators.

Quite clearly, Spelman perceived the tendency of historians to antedate the emergence of the modern. In his tract *Of Parliaments* he went back to the feudal Great Councils and addressed himself to the problem of determining, if possible, when Parliaments, in the later meaning of an assembly of the three estates of the realm, came into existence. He said: ". . . our later Chroniclers following Polydore [Vergil], as it seemeth (for they cite no Author) do affirm that *Henry I* in the sixteenth Year of his Reign, held the first Parliament of the three Estates. The truth whereof I have taken some pains to examine, but can find nothing to make it good." He then appealed to Eadmer, a chronicler who wrote during the reign of Henry I, and to the chronicle of Florence of Worcester, who lived about the same time, to show that there was no good reason to believe that commons were present at Great Councils under Henry I. "I no where find," Spelman continued, "in all the Councils (or Parlaments [*sic*], if you so will call them) of this time, any mention made of any other than the Bishops, Barons, and great Persons of the Realm. And so likewise in the time of King *Stephen*." It is superfluous to remark that present-day scholarship is here entirely at one with Spelman.

Our final quotation to illustrate Spelman's insight as a historical critic, his appreciation of the historically distorting effects of present-

[29] Maitland, F. W., *The constitutional history of England*, 142, Cambridge Univ. Press, 1911.

mindedness, is the opening paragraph of this same tract, *Of Parliaments*. It may be left without comment, to speak for itself:

When States are departed from their original Constitution, and that original by tract of time worn out of Memory, the succeeding Ages, viewing what is past by the present, conceive the former to have been like to that they live in; and framing thereupon erroneous Propositions, do likewise make thereon erroneous Inferences and Conclusions. I would not pry too boldly into this Ark of Secrets: But having seen more Parliaments miscarry, yea suffer shipwreck, within these sixteen years past, than in many hundred heretofore, I desire for my Understanding's sake to take a view of the Beginning and Nature of Parliaments; not meddling with them of our time, (which may displease both Court and Country), but with those of old; which now are like the Siege of *Troy*, matters only of Story and Discourse.[30]

[30] *Of parliaments* can be found in *The posthumous works of Sir Henry Spelman Kt.*, referred to in note 4, above, as can also *The original, growth, propagation, and condition of feuds and tenures by knight-service in England* and *Of the ancient government of England*.

ORIGIN OF THE MOON AND ITS TOPOGRAPHY

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The purpose and scope of this paper are indicated in the summary at the end.

INTRODUCTION

GEOLOGY, a study of planetary evolution, is itself in evolution; the plunge of this comparatively young science into the unknown has brought many pearls of ascertained truth, but for every major principle established at least one new major problem has cropped out. Even new techniques have to be learned and applied. An outstanding illustration is found in the attempt to determine the amount and distribution of the earth's internal energy, particularly the heat. This fundamental question is forcing students of geological dynamics into the field of cosmogony. Whatever be the role of radioactivity in rocks, it is clear that the importance of primitive heat must be valued. Where there is so much darkness every ray of light is welcome, and it was with sure instinct that Eduard Suess and Thomas Chrowder Chamberlin a half-century ago sought new light from cosmogony and from comparison of earth and moon. These masters and others, later on, have been asking a multiple question: what relation have theories of the moon's origin to problems concerning: (1) terrestrial volcanism, igneous action in general; (2) the differentiation of sialic and simatic shells of the outer earth;[1] (3) the theory of isostasy in explanation of the earth's relief—a theory implying mechanical contrast between a strong crust (the lithosphere) and an immediately underlying weak layer or shell (asthenosphere); (4) theories of mountain-building; (5) the theory of the sealevel figure of the earth; and (6) the existence of continents standing shoulder-high above the floor of the deep ocean?

Fruitful comparison of planet and satellite has been greatly broadened and deepened by two recent developments: geophysics on the one hand and adequate photographic and other instrumental study of the lunar surface on the other. Some selenographers claim that the visible 59 per cent of the moon's surface is better mapped than the earth's surface as a whole. We now know of startling contrasts of topographic form in the two bodies—of remarkably few similarities among the details. Since Galileo's day many astronomers have been unduly stressing similarity of topographic forms and similarity of genesis of those forms. A large number of astronomers as well as some geologists have regarded most of the 30,000 visible pits on the lunar surface as volcanic vents whose energy resided in the heat and gas of the interior. Published in 1895, the classic paper by Grove Karl Gilbert, one of the keenest observers and most logical thinkers who have worked in earth science, contained a powerful argument for the very different impact or bombardment theory of the lunar pits, which nevertheless will probably long continue to bear the unlucky name "craters."

Thus today selenographers are divided into two groups. One emphasizes internal influences as shaping the rugged moon; the other emphasizes external influences. This difference of judgment is likely to persist until the origin of both earth and moon has been finally established. No thoroughly satisfactory theory of those beginnings and of the solar system in general is yet in sight. However, some astronomers and geophysicists have most satisfaction in assuming an initially gaseous state for the earth, and this idea seems to furnish the best basis for thought about the evolution of the earth-moon

[1] "Sial" is mnemonic for rock or rock-melt which is relatively rich in silica and alumina (plus alkalies). "Sima" is mnemonic for rock or rock-melt which is relatively rich in silica and magnesia (with little or no alkali). Sialic material, typified by granite, is less dense than simatic material, typified by basalt or peridotite.

system. The present paper is chiefly concerned with the hypothesis that some or all of the moon's material was torn out of the young earth. New variants of the fission theory as well as a capture hypothesis are to be described and then tested by the facts known about the composition, density, topography, and other characteristics of our satellite.

PUBLISHED IDEAS OF "ULTIMATE" ORIGIN

What was the earth like at its birth? No attempt will here be made to canvass all the possibilities suggested by students of this controversial subject, but a brief word about the latest ideas is not out of place.

Since the beginning of the present century cosmogonists have taken seriously the speculation that by the close approach of, or actual collision with, a visiting star, the sun, or possibly a companion of the sun, or all three of these, lost enough gaseous substance to build our planets and satellites. The speculation was at once adversely criticized on the ground that a close approach of a wandering star to the sun is extremely improbable, but this objection loses some of its force if, as reported, the stars of our galaxy were formerly much closer together than now and correspondingly more liable to mutual close approaches. What appears to be a more stubborn trouble has been indicated by Lyman Spitzer (1939). His reasoning, summarized by Whipple (1941: 237), is that gas torn out of the sun, in mass equal to our planets and satellites, would be so hot (compare Russell, 1935: 111) that it would explode and with such velocity of dispersal as to forbid condensation to planetary forms; the gas would be completely dissipated in the depths of space. However, Whipple suggests a possible way out of the difficulty: dissipating explosion would not occur if the solar disruption were relatively slow, and he believes it wise to retain the hypothesis of stellar disruption for our planetary system.

Two other modern explanations of that system may be mentioned. That of Nölke (1930, 1931) also demands a gaseous state and high temperature for each planet at its birth. The still more recent hypothesis of Weisäcker (see last footnote of the present paper) derives the planetary system from a cool nebula revolving around the sun, the nebular material being gravitatively segregated into many rotating, solid bodies. Even if Weisäcker's suggestion should be found to give the best solution to the long-standing problem, it does not preclude a gaseous state for a planet which was formed by the collision of two large masses segregated in the nebula.

A more complete listing of the many published cosmogonic schemes is not needed to enforce the conclusion that, according to the more stalwart of these hypotheses, each of the existing planets was initially hot enough to be gaseous. At any rate let us make this assumption, thus cutting the Gordian knot of uncertainties, and then with that assumption trace the evolution of the earth-moon system in a speculative way.

Because of radiative and adiabatic cooling the smaller planets condensed to liquid, rotating globes, each, through rapid molecular flight into space, having been reduced to a mass much smaller than it had when in the initial, gaseous state. In his book, *The Earth*, Jeffreys showed it to be doubtful that the moon could have come into being through condensation from a mass of stellar gas which had never been part of a larger, truly planetary mass. He supports the view of astronomers in general that the partnering of earth and moon demands a special explanation—one quite different from any that may prove to be true for the other satellites of the solar system.

The most elaborate attempt to account for our own satellite was made by George H. Darwin, using the results of his study of the moon's motions. He proved that, before it began its spiralling journey away from the earth (because of tidal friction), the centers of the two globes were no more than two or three earth-radii apart, the day then being about four hours long and a little shorter than the month. The nearness of the bodies was such that Darwin (1908: 455) thought it natural to suspect the moon to have been originally part of the earth. This suspicion of the great geophysicist is indeed one of the important reasons for the writing of the present paper.

Darwin took the angular momentum of the earth-moon system at the epoch of their separation to be the same as the total angular momentum at the present time, as it had to be if the system has kept constant mass and has not undergone dynamical interference from outside. With a four-hour period of rotation the earth was stable, even when liquid at the surface.[2]

[2] Darwin took no account of the high probability that the earth's iron core had already been separated from the silicate mantle at the epoch he was considering, but this omission is in principle not essential in itself for decision as to the possibility of fission by tidal resonance.

To eject the moon by centrifugal force alone the period of its rotation would have been no more than about three hours, but such rotational velocity could not be reconciled with the necessity for constancy of angular momentum belonging to the system.[3] Darwin thought that actual separation of the two bodies might have been brought about if the considerable rotational strain corresponding to a four-hour day were much increased by resonant upbuilding of the solar tides in the young, liquid earth. He supposed resonance to have added tidal amplitude to tidal amplitude in long succession until from the mounting bulge liquid silicate flew off and became by self-gravitation the globular moon—a separate body.

This brilliantly expounded hypothesis accounts well for the extraordinarily high mass ratio of moon to earth when compared with all other ratios of satellite to primary in the solar system; and also accounts well for the proved close approach of the infant moon's orbit to perfect circularity. Moreover, Jeffreys has shown how Darwin's essential idea might be a basis for explaining the mean density of the moon and the apparent fact that, unlike earth, Venus, and Mars, the moon has no iron core.

But there is an obvious and formidable difficulty: could the terrestrial liquid have mobility enough to give the required elongation at the equator? To produce the fission the tidal bulge, with height of more than four hundred miles, had to be built up and annulled every two hours. Recent experiments on organic liquids and on one hot glass (borate) show that with increase of all-sided pressure the friction opposing internal shear rises according to logarithmic laws, so that one must doubt sufficient mobility for the shells of the young earth. This doubt was strengthened when Jeffreys (1930: 169) made a quantitative study of the subject.

Darwin's hypothesis faces a second difficulty if his mathematical analysis be taken to prove an initial, center-to-center distance of only 9,000 miles between earth and separated lunar material (see Russell, 1935: 129). Darwin (1908: 359) pointed out that "if the moon were to revolve at a distance of less than 2.86 [earth-] radii, or 11,000 miles [Roche's limit], she would be torn to pieces by the earth's tidal force." He did not clearly indicate how the pieces could ever have been agglomerated to form the existing lunar globe.

Nölke (1931: 56) has offered a third objection: even if the crown of the exaggerated tide were torn off, this mass would have to fall back into the earth.

Although it is probable that the tide-resonance explanation of the moon must be discarded, Darwin's investigation is of permanent value, giving results as important as they are secure in principle. He found for us the amount and distribution of angular momentum in the earth-moon system.[4] As already observed, he discovered the clear fact that the two bodies were once close together, and he showed why they separated so far—at first rapidly and then with increasing slowness. He showed why we can see only 59 per cent of the moon's surface, and he firmly founded the premise on which Jeffreys (1929: 229) has so well explained the moon's elongation toward our planet. All these determinations are full of meaning for the moon problem.

What condition other than tidal resonance could have brought about the separation of much or all of the moon's substance from the young earth? Was the primary condition internal or external? To neither query can a definite answer now be given, but the writer, feeling keenly the importance of both for his own science of geology, offers herewith some speculations which may possibly engage the attention of better judges of their merits.

Manifestly such guesses must be founded on a general conception of the earth's beginning. Together with a stellar origin, initial gaseous state, and corresponding high temperature, it is assumed that the terrestrial gas-ball was chemically a mixture of stony-meteorite and iron-meteorite material with much hydrogen and helium; and that the initial mass was several times that of the existing earth-moon system, the excess having been lost by molecular flight into space and perhaps also by catastrophic explosion.

Jeffreys (1929: 35) has shown reason to think that the liquefaction of such a massive gas-ball would be guaranteed more by surface radiation than by adiabatic expansion and cooling. He supposes liquefaction to have been a straight-

[3] Ross Gunn (*Jour. Franklin Institute* **213**: 655, 1932) has recomputed the length of the day just before fission and found it to be 4.1 hours; he also concluded that the liquid earth would have been unstable if its day were 3.3 hours long.

[4] The revolving moon now carries 4.82 times the angular momentum of the rotating earth.

forward process, liquid droplets formed in the chilled gas falling to the center of the ball, there to accumulate until the whole became liquid except for an atmosphere of trivial mass. The droplets of iron, olivine, and other substances with high boiling-points were the first to appear and sink toward the center. Droplets of compounds with lower "points" for boiling were formed later and in general were endowed with densities smaller than those of the first crop of droplets. For both reasons it would seem inevitable that the planet, when wholly liquid, was stratified by intrinsic (chemically determined) density. This type of layering could hardly favor deep convection; yet Jeffreys assumes cooling by thermal convection and consequent pressure-crystallization of the whole silicate mantle, the solidification beginning at the bottom and rapidly extending to the surface. His theoretical scheme implies that, just before the moon became a revolving partner with the earth, the planet had at most only a slight excess of mass over its present mass; that the day was about four hours long; and that therefore the rotation of the earth was too slow for ejection of material ultimately constituting the moon as a coherent, independent body.

If that evolutionary scheme be adopted, the partnering of the moon must be ascribed to an agency external to the condensing but already liquefied earth. Such an agency will be suggested later, but beforehand it may not be amiss to speculate as to whether, because of an internal condition of the earth, the moon was torn out when the planet was still largely gaseous—that is, at a stage earlier than the one chosen by Darwin.

Whether the agency was external or internal, it will be supposed to have operated when the earth was surfaced with a thick layer of ultrabasic liquid (with composition much like that of the average achondritic meteorite), and thus at a time before the granitic and basaltic earth-shells were differentiated.

INTERNAL INCENTIVE TO FISSION

According to our basal assumptions the terrestrial gas-ball had at the beginning of its history the following characteristics: (1) a high proportion of hydrogen and helium, in which the materials of the silicate mantle and iron core of the existing earth (these having the composition of meteorites) were "diluted"; (2) a corresponding excess of mass; (3) internal temperature much higher than that due merely to the self-compression of the ball;[5] (4) rotation about an axis highly inclined to the plane of revolution around the sun. (Compare Daly, 1943.)

Without delay three major changes would be expected: dissipation by molecular flight of most of the hydrogen and helium into space; condensation of the residual gas; and formation of liquid droplets of metallic iron and silicate having high boiling-points, to be followed by droplets of silicates with lower boiling-points. To picture correctly the details of general condensation is beyond the writer's power, but it seems reasonable to suppose that there was a stage when a surface layer of liquid was in floating equilibrium on iron-rich and therefore denser material in the critical state, and this to the center of the ball.[6] Let us assume that the liquid layer was a few hundreds of kilometers in thickness, the mean radius of the inner spheroid of "supercritical gas" being about 8,000 kilometers and thus 1,600 kilometers greater than the mean radius of the earth at present. Let us suppose that, as a result of the condensation, the period of rotation had by now been shortened to about three hours. Darwin's mathematical analysis shows that the ball would be unstable, a large mass of the liquid being thrown off at some point in the equatorial zone. The sudden release of pressure on the supercritical gas in the same earth-sector would cause this material to flash into highly explosive gas. Once started, the explosion would lead to the evisceration of the whole equatorial zone.[7] The explosion would be likely to eject both liquid and gaseous substances at speeds above the escape velocity corresponding to the attraction of the original spheroid, and exceeding in still greater measure the escape velocity corresponding to the attraction of the residual planetary mass.

After the explosion the residual mass would assume the form of a stable spheroid because of equatorward flow of liquid from the polar sectors,

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[5] Nölke (1931: 65) estimates the initial temperature at the center of the earth-ball at something like 50,000°C.

[6] At this stage we have an analogy with the pictures of the existing earth as drawn by Günther (1897: 358) and Arrhenius (1900).

[7] Nölke (1931: 65, 67) has suggested that under certain circumstances the cooling and condensation of a planetary gas-ball would not be a straightforward process dominated by radiation from a spheroidal surface but would be interrupted by catastrophic explosion of the body, with of course great, though temporary, acceleration of the cooling by both adiabatic and radiative means.

where the liquid had had low rotational velocity. Let it be assumed that, when equilibrium was established, the mass of the diminished earth had become about equal to the existing mass, that the day had been lengthened to four hours, and that the spheroid was still liquid at the surface. These conditions are those accepted by Darwin for the epoch when the moon was close to the earth.

Some individual masses of the liquid matter ejected during the explosion would be expected to have travelled with less than the escape velocity corresponding to the attraction of the original ball, but would not fall back and be absorbed by the diminished earth, with much smaller power of attraction. Such fragments would therefore remain in permanent revolution. The largest of the earth fragments would attract and in the course of time absorb smaller ones until an independent, revolving spheroid with the dimensions of the moon would be developed. On account of its small size the moon would soon be crusted and its solid surface would become pock-marked with late-coming earth-fragments.

The orbits of many other earth-fragments sent flying by the explosion would undergo perturbations and ultimately fall into the planet, which, because of its great size and inherited high temperature, would still be liquid at the surface and thus would bear no permanent scars of such bombardment.

In review, the guess that the earth carried within itself the potential for the birth of the moon is seen to be no more than a hypothesis *ad hoc*. One of its chief purposes is to reconcile the idea of fission by rotational instability with the deficiency of angular momentum in the existing earth-moon system—a deficiency demonstrated by Darwin. To make the reconciliation, the chain of pure assumptions, all incapable of direct verification, is too long for ease of mind. To illustrate the truth that other guesses about the genetic relation between planet and satellite should be put into competition, the writer offers two other conceivable solutions to the problem. Each of these ascribes the separation of the lunar material from the earth because of an external influence.

EXTERNAL INCENTIVE TO FISSION

According to the first of the alternative solutions, the conditions of hypothesis no. 1 are assumed, but the eviscerating explosion of the superheated gas is now supposed to have been triggered off by local, preliminary explosion and expulsion of matter through heating by collision with a planetoid which arrived with great relative velocity. It is thought that such a preliminary explosion could relieve the deep-lying supercritical material from enough weight-pressure to cause it to flash into the gaseous state, with evisceration, loss of mass, and reduction of planetary rotation, as imagined in hypothesis no. 1. To formulate this no. 2 hypothesis we have piled speculative Pelion on speculative Ossa and in so doing have encountered new mental trouble. For example, it would be hardly possible to tell the proportions of the moon's mass assignable to fragmented planetoid and fragmented earth respectively.

Obviously either hypothesis no. 1 or hypothesis no. 2 can be formulated with a good deal of elasticity in the assignment of masses, velocities, and temperatures without destroying all worth of the speculation. The same is true of still another fundamental assumption, the terms of which have been elaborated from a directive given in a personal letter from Professor H. N. Russell. He suggested that it might be worth while to study the question whether the main part of the moon's substance represents a planetoid which, after striking the earth with a glancing, damaging blow, was captured. Acting on that hint, the writer has developed hypothesis no. 3, with the following additional postulates: that at the epoch concerned the earth had practically its present mass and was liquid at the surface; that the planetoid had direct motion and struck the earth at or near the equator; and that fragments were torn off directly by the visitor, along with others ejected because of an explosion resulting from the collision.

A preliminary word about the nature of the planetoid is in order. Jeffreys (1929: 28) found no planet with radius smaller than about 2,000 kilometers—200 kilometers greater than the lunar radius—could be formed by the condensation of gas derived from the sun or similar star. The telescope shows how few are the known bodies with radii exceeding 2,000 kilometers, and Bode's law provides no place for a planet whose orbit is now situated between the orbits of earth and Mars or between those of earth and Venus. It is therefore not easy to think that the colliding planetoid as such had independent existence from the beginning of the solar system. With more plausibility our planetoid may be supposed to have originated during Jupiter's

tidal disruption of the planet whose debris is now partly represented by the asteroids (see Jeffreys, 1918: 435), or else to have originated when this parent planet blew itself to pieces (see Russell, Dugan, and Stewart, 1926: 357). The hypothesis of tidal disruption has some support from the consideration that, if the parent of the asteroids did approach Jupiter so closely, the orbit of the parent around the sun was highly elliptical and its path would have to pass within the earth's orbit. In a personal interview Professor Whipple noted a second possibility: that the odds in favor of the collision might have been increased if at that time the earth were near the aphelion of an orbit more elliptical than its present orbit around the sun. It is of course conceivable that more than one asteroid entered the gravitational fields of both earth and younger moon and were absorbed by these two bodies.[8]

The first effect of the impact of the "planetoid" on the liquid earth would be violent splashing all around the locus of contact, and each splash would have large components of its velocity in the horizontal and vertical directions. (Compare the effects of shell-fire on a military target as described by Cranz and Becker, 1921: 445.) Also violent would be similar dispersal of fragments caused by gaseous explosion if the "planetoid" had a large fraction of the moon's present mass. Supposing the infall to have been at the minimum velocity, namely, that due merely to the earth's attraction or 11 kilometers per second, the heat developed would have sufficed to raise the temperature of the planetoid by about 40,000° C. if this heat were evenly distributed through it. But in fact most of the heat would have to be concentrated at the interface between the two bodies, for along that interface would be the maximum of plastic deformation. Hence it does not seem wild to assume a temperature of at least 100,000° C. on both sides of the interface. Such heating means volatilization of much material in this region. Although the depth to which the planetoid penetrated must be an uncertain quantity, we can easily suppose that, even with a collision of the slicing kind, the locus of volatilization would be far below the planetary surface. At this depth would be located most of the explosive energy.

The explosion would drive out terrestrial material into a limited belt ringed about the planetoid. Many of the initially liquid fragments would be swept along by the visitor as it left its grazing contact with the earth, and by mutual gravitation would fall into the planetoid remnant, ultimately developing a revolving body with the mass of the existing moon. There seems to be no *a priori* objection to the idea that the new satellite was at first largely or wholly liquid, or to the supposition that after the crusting of the moon it was bombarded by late-coming earth-fragments which left permanent record in the form of the visible lunar "craters."

This third hypothesis shares difficulties connected with current theory about the development of the solar system as a whole, and has troubles more peculiar to itself. First, we have to consider how small is the chance that an asteroid or planetoid of any other origin would strike the earth near the equator. On the other hand, as Jeffreys (1929: p. 37) points out, our moon is unique among all the satellites of the solar system, and it seems allowable to postulate such a highly specialized condition for the moon's origin. Secondly, it is natural to think that a satellite which in large part represents captured material should have had an initial orbit of considerable ellipticity; if so, the problem of explaining the reduction to the approximate circularity of the lunar orbit emerges. Here too there is a theoretical solution of the difficulty: appeal to the same "resisting medium" by which cosmogonists now account for the approximate circularity of the planetary orbits.

In passing, it may be remarked that those two difficulties do not exist in the case of hypotheses nos. 1 and 2. On the credit side, however, no. 3 seems to afford a better basis for accounting for the reported (though not fully demonstrated) triaxiality of the sealevel figure of the earth. Like the other two hypotheses it avoids the difficulty emphasized by Darwin: it offers explanation of the earth-moon system in spite of the fact that the angular momentum of the system is now too small for the fission of a planet with a four-hour day and the mass of the existing system.

EARTH-FRAGMENT HYPOTHESIS

Three guesses have been made as we have ranged over a wide field of mystery. We have

[8] If the "planetoid" were one of the asteroids, its mass was additional to the total for the visible asteroids. By so much would we be better able to account for the fact that the total mass of known asteroids is far smaller than the minimum mass required on the theory of planetary derivation from the sun (see Jeffreys, 1929: 28, 62).

met uncertainties at every turn, and the most vital is the possibility that a thoroughly contrasted fourth guess might hit the truth. Perhaps, however, our speculative exploration makes more tolerable the idea of catastrophe, followed by the infall of terrestrial fragments into, and during the growth of, the moon. In any case let us accept the idea as correct, while leaving wide-open a choice among the conditions that led to the expulsion of fragments from an earth liquid at the surface—fragments later conglomerated to make the independent, revolving moon. Then let us see how this "earth-fragment hypothesis" agrees with the facts of selenography, geophysics, and geochemistry. Here the jungle of uncertainties is not quite so thick.

First, the composition of the moon demands attention. Our fundamental assumption as to the meteoritic composition of the earth makes it easy to believe that, at the moment of fission, the thick superficial, liquid shell yielding much or all of the moon's substance was "peridotitic" and held considerable volatile matter in solution. If freed of gas and crystallized at the pressure of one atmosphere the material would have a density close to 3.33, the mean density of the moon at present. If a part of the moon represents a captured asteroid, that part might well have now the density of Eros or Ceres, again not far from 3.33, a suggested value which, however, has not yet been actually proved for these two bodies. The internal pressure of the moon increases the one-atmosphere density of its material by about 0.1, but we may expect this increase to be largely or quite offset by vesicularity, due to the sudden release of dissolved gas, as bubbles, in the flying fragments from which much of the lunar globe was developed.

From measurements of the polarization angles of the moon's surface, Lyot (1929: 140) of France and Pettit and Nicholson of the Mount Wilson Observatory, as reported by Wright (1935: 113 and 1938: 67), found the surface material to react like volcanic ash or pumice. From the measured rates of cooling and heating during and after eclipses a vitreous (pumiceous) condition was suggested to Wright, whose committee is carrying on the most thorough investigation of the moon yet undertaken.

In the course of time the stony-meteorite material of the earth's mantle became differentiated into the granitic, basaltic, and peridotitic layers of the present day. Similar differentiation may have developed homologous shells just below the surface of the moon; if so, the results of the optical tests find rather direct explanation, though the uppermost, "sialic" layer may not be quite so high in silica as the granitic shell of the earth. In any case we should expect the surface material of the moon, exposed to the low gravitational pressure in our satellite and made rapidly viscid through free radiation of heat, to be vesicular to this day.

In any of its forms the catastrophe hypothesis as here presented implies the absence of a volumetrically important iron core in the moon—a fact demonstrated by the mean density of the body.

Another supporting fact is found in the shape of the moon. According to leading geodesists the sealevel figure of the earth approaches that of a triaxial ellipsoid, one with an elliptical equator. Such a figure means that the deeper and greater part of the planet is capable of resisting indefinitely considerable shearing-stresses. The required strength may well be attributed to pressure-crystallization of that part of the silicate mantle which lies between the iron core and a level somewhere between 500 and 1,000 kilometers from the surface. From this level to the base of the lithosphere at average depth of about 70 kilometers is an asthenospheric layer still too hot for complete crystallization. Now the solid figure of the moon also approaches a triaxial form. "From Hayn's discussion it appears that the equatorial diameters of the moon differ by about one third of a mile, while the polar diameter is fully a mile less than the shorter of these" (quotation from Russell, Dugan, and Stewart, 1926: 170).

Jeffreys has given the only good explanation yet offered for this departure of the moon's figure from that of an oblate spheroid in fluid equilibrium. He assumes that for a relatively short but sufficient time the infant moon was either liquid at the surface or but thinly crusted. Using the theory of tidal friction produced by the powerful tides set up by the earth's attraction, he calculated an approximate date for the stereotyping of the tidal bulge to which the moon's triaxiality is to be referred. He found that the bulge, containing the longest equatorial diameter and centering in that face of the satellite which henceforth was to point toward the earth, was fixed in position when moon and earth were about 140,000 kilometers (30 per cent of the mean radius of the lunar orbit at present) apart.

At that comparatively early date enough of the moon must have been crystallized and thus become strong, to permit permanency for the earth-directed bulge. Allowing for the speediness of pressure-freezing in depth and the rapidity with which so small a body cooled, one can well see how that condition was met. Jeffreys' success in solving his problem tends to corroborate a leading premise of the present writer's catastrophe hypothesis, namely, primitive liquidity and correlated high temperature both for the earth and for the matter which was ultimately aggregated to form the moon's body.

LUNAR TOPOGRAPHY

Finally, the suggested mode of genesis will be considered in relation to the relief of the moon. Here we have a wealth of facts, expressed in the books of Elger, Neison, Nasmyth and Carpenter, Shaler, Graff, Fisher, and others, as well as in the magnificent photographs of the moon taken at the Paris, Lick, and Mount Wilson Observatories. Of unique value is the sumptuous lunar atlas of Loewy and Puiseux, representing a dozen years of photographic study at the Paris Observatory. The older, hand-drawn maps of Baer and Maedler, Schmidt, and others are historically important and of permanent value, but for many purposes not so useful as the photographs. The following discussion will be largely confined to the so-called "craters," rayed and unrayed, and the maria.

We have seen that, according to the favored explanation of the moon's origin, its silicate material was initially hot enough to be liquid at the surface and held much gas in solution; that some free gas was present in the terrestrial fragments; and that later on additional gas was probably freed by the pressure-crystallization of silicate in the depths of the lunar globe. It is therefore natural to look for signs of moderate volcanic action in the moon's topography. In fact no other explanation seems so plausible for certain rows of small, alined pits, typified by those in the vicinity of the Bulliadus and Stadius "craters." Such comparatively minute, supposedly true craters are to be numbered in scores if not in hundreds; yet their total area is but a small fraction of the visible surface of the moon.

Many selenographers have been inclined to accept a similar origin for the thousands of much greater depressions—walled plains, mountain-rings, crater-plains, and "craters" of Neison's classification. For this conclusion there is little convincing argument. In its support emphasis has been placed on a fancied homology with the greater terrestrial depressions due to major volcanic explosions, and also with the volcanic sinks (unfortunately named "calderas") of Hawaii.

The first of these claims to true homology is at once suspect when one compares the characteristic asymmetry in the ground-plans of these terrestrial "craters" (calderas) of evisceration with the high degree of symmetry for the lunar depressions. Other contrasts are found in great disparity of size, in relative abundance, and in distribution over the respective surfaces of planet and satellite. In none of these respects is volcanism of the explosive type a good explanation for the many thousands of larger "craters."

The suggestion of J. D. Dana (1846), followed by that of W. H. Pickering (1906), that the Hawaiian sinks may more truly represent the ringed depressions of the moon is likewise unsatisfactory. The Hawaiian sinks are surface effects of slumping, caused largely by withdrawal of lava through fissures that have been opened in the mighty lava-dome of Hawaii, this withdrawal being possible because the high elevation of the visible dome above the Pacific floor affords the required condition for the draining of lava from the active pipes or conduits. In the moon there is no such difference of level to induce important withdrawal of lava in depth.

The lava rings of Hawaii have the general shape of the larger "craters" of the moon, but this likeness can hardly be taken to mean similar origin. The lava rings, with diameters of a few scores or hundreds of feet, represent retaining dams built up by marginal chilling (solidification) as the levels of the respective lava lakes slowly rose. The more or less circular dam remained as a ring-shaped ridge after the lake level finally sank away. The lake itself was kept liquid by lively "two-phase convection" in the conduit which had a cross-section much smaller than the area of the lake. It seems out of the question that the moon could have kept issuing gas at such a rate that any of the "craters," with individual areas thousands or tens of thousands of times greater than the area of any Hawaiian lava lake, were floored with lakes made or kept liquid in the same way. Moreover, the circular ridges of the Hawaiian lava rings have

relatively smooth longitudinal profiles, in contrast to the wonderfully jagged profiles of the lunar rims.

It is particularly hard to regard as volcanic the numerous small pits which are sunk in the high, massive rims of the larger "craters." From the Loewy-Puiseux atlas the writer has made a list of 52 of such damaged rims. The list is not complete and yet includes 10 per cent of all the named "craters." The high rims are among the last places on the moon where a geologist would expect to find so many gas vents.[9]

Further, the theory involving volcanic explosion is suspect because it fails to account for the relatively low albedo of the lunar regions which are crowded with "craters." At each of these the explosion of gas brought up from the interior of the moon should have led to the deposition of abundant chlorides, sulphates, and probably free sulphur. Whether salt or element, the sublimates reflect light much better than does pumice or any of the standard rocks, whether comminuted or not. The observed proportion of solar light reflected from the "crater"-rich areas is clearly not that expected from a blanket of sublimates, widely spread from each of the many thousands of "craters." Thus once again a logical consequence of the volcanic hypothesis does not agree with fact.

The advocates of that hypothesis have paid too little attention to another fact: under even the best conditions for seeing no selenographer has been able to identify unequivocally lava flows that issued from any of the "craters." The great spurs radiating from Copernicus, Aristillus, and a few others have dimensions of a quite different order and find easier explanation as gigantic splashes of impact.

Gilbert (1895: 246) was one of the first geologists to attempt quantitative comparison between terrestrial volcanic craters and lunar "craters," with respect to abundance, size, and form. Recommending caution in using the first criterion, he wrote: "Had the terrestrial craters of all periods been exempt, like those of the moon, from atmospheric and aqueous attack, it is easy to imagine that they might now be equally abundant." He found the striking contrast in diameters to be only in small part explicable by the different values of gravity in the two bodies, while "in vertical dimensions there is no important discrepancy." Still more compelling reasons for discarding the volcanic theory for the lunar "craters" were detailed when Gilbert discussed the third criterion, form. First, he considered terrestrial volcanoes of the Vesuvian type, 95 per cent of all the visible vents. Ninety-nine per cent of the Vesuvian volcanoes, more or less conical piles, have the bottoms of their craters higher than the corresponding outer plains, while an equal proportion of the lunar "craters" have their bottoms lower than the surrounding plains. Further:

> Ordinarily the inner height of the lunar crater rim is more than double its outer height; ordinarily the outer height of the Vesuvian crater rim is more than double its inner height. The lunar crater is sunk in the lunar plain; the Vesuvian crater is perched on a mountain top. . . . The smooth inner plain characteristic of so many lunar craters is either rare or unknown in craters of the Vesuvian type.

Gilbert concludes:

> Thus, through the expression of every feature the lunar crater emphatically denies kinship with the ordinary volcanoes of the earth. If it was once nourished by a vital fluid, that fluid was not the steam-gorged lava of Vesuvius and Etna.

The present writer believes that this argument of Gilbert holds good even if it were proved that in its infancy the moon ridded itself of volatile matter with the explosive power of a Vesuvian volcano.

Concerning volcanoes of the Hawaiian type, Gilbert wrote:

[9] The old "blister" theory of Hooke and Secchi can hardly apply to these pits on the "crater" rims, and in general, like the laccolithic theory originating with Tomkins (1927) and recently approved by Marshall (1943), has little to commend it.

On the Oceanus Procellarum and on some of the maria the lava surface at many points bears smooth, circular, or elliptical domes which have major diameters of one to three miles and heights of a few scores or hundreds of feet (see Elger, 1895: 6; Shaler, 1903: 37, 38; Marshall, 1943: 424). One might be tempted to think of the domes as homologues of the low domes ("tumuli") so often seen on the earth's basaltic flows of the pahoehoe type. However, these last rarely reach lengths exceeding sixty feet and their crests are seldom as much as twenty feet above the surrounding plain of lava, and the disparity of size tends to make incredible any true homology between the "tumuli" and the lunar domes, even allowing for the low value of gravity on the moon. Moreover, if there were a true homology, the domes could not be considered evidence of as many tappings of gas from the deep interior of the moon, that is, evidence of true volcanism. An apparently much better explanation is that these domes represent older "craters" or isolated reliefs which were flooded and smoothed over by lava of the maria, and then left standing up after the flooding lava sank away on all sides of each dome.

As long ago pointed out by Dana, they resemble the moon's craters much more closely than do those of ordinary volcanoes. They agree with lunar craters in the possession of inner plains, and to a certain extent in the terracing of their inner walls. They differ in the fact that they occupy the tops of mountains; in the absence of the wreath; in the absence of the central hill, and usually in the presence of level terraces due to the formation of successive crusts. In my judgment the differences far outweigh the resemblances, and I have not succeeded in imagining such peculiarities of local condition as might account for the divergence in form.

Finally, Gilbert discussed volcanoes belonging to the remaining terrestrial type of volcanoes, namely the maars, each of which is small and represents "an explosion of steam," unaccompanied by emission of lava. He thought it possible that such vents might be identified on the moon if it were possible to have the "better seeing" necessary in the case of a relatively minute feature like a maar.

Gilbert phrased his general conclusion as follows:

> The volcanic theory, as a whole, is therefore rejected, but a limited use may be found for the maar phase of volcanic action in case no other theory proves broad enough for all the phenomena.

The arguments of the master must be given special weight because they are those of a geologist who had had extensive field experience in volcanic fields and in his profession was almost unrivalled with respect to rigor of thought and fairmindedness in controversial matters. Since he wrote, a good many investigators, most of whom have never made serious study of terrestrial volcanism, have discarded the volcanic theory of the lunar pits, but few of them have so explicitly based reasoning on quantitative considerations.

Suess (1895 and 1918) was so impressed by the size of the "craters" that he was led to regard them as loci of regional fusion of the crust. To supply the needed energy he assumed a colossal amount of superheated gas in the moon's body, and thought that this gas emanated at points around which the crustal fusion took place. For Suess the lunar refusions were homologues of the regional refusions of the earth's crust by rising batholithic magma, and he seems to have relied on the collection of extremely hot gas from the deep interior as a sufficient cause of the superheat of the magma itself. However, it is now clear that so great superheat cannot be postulated for terrestrial magma. According to Suess, the high rims, the characteristic boundaries of the lunar depressions, were formed in two stages: first by the peripheral chilling of the lava derived by crustal refusion and spread over the moon's surface; and by later subsidence in the broad central area of each region of refusion. Here he relied on Ebert's experiments, intended to duplicate the effects of crustal refusion. No homologues of the results of these experiments are known to be represented anywhere in terrestrial geology on the scale of the lunar maria, and one may well question the relevancy of Ebert's experiments which failed to reproduce the spectacular ruggedness, serrateness, of the rims of the lunar "craters."

Thus all published versions of the volcanic hypothesis face serious difficulties, and in the writer's opinion there is much more hope of success in accounting for the large, dominant depressions on the moon as primarily the results of as many infalls.

We now return to our main line of thought—appraisal of the earth-fragment hypothesis. We must suppose many of the fragments torn out of the earth to have been projected beyond Roche's limit. For the earth this limit is about 11,000 miles or 17,500 kilometers from the center. Inside the limit any fragments would have been comminuted by the earth's powerful attraction and the aggregation of these by their own mutual attraction would be impossible, just as in the case of the particles in Saturn's rings. It is out of the question to declare the range of sizes for the flying fragments; yet it is not unduly straining probability to assume that one of the earth-fragments or else a wrecked and captured planetoid, safely outside Roche's limit, was large enough to gather in with comparative speed the other fragments, thus growing to the mass of the existing moon. Rapid radiation might well have developed a continuous crust before many of the laggard fragments were gathered in. Would not the scars made by these late infalls account for the great majority of the lunar "craters"? Tests leading to an (affirmative) answer to this question will be the next subject for discussion.

Among the facts to be accounted for are: (1) the great sizes of the typical "craters"; (2) the close approach of their rims or "wreaths" to circularity; (3) the composition, remarkable heights, and often-extreme ruggedness of the

rims; (4) the relative smoothness of floors; (5) the large number of cases where each "crater" is provided with a central peak; (6) the light-tinted rays emanating from a few of the great pits; and (7) the relation of the "craters" to the maria which occupy so much of the moon's face.

Permanent scars due to impact obviously mean true solidity for the surface material. This is thought to have been early secured by crystallization of the differentiated sialic or quasi-sialic layer. On account of the low value of lunar gravity such a crust need not have exceeded about 10 kilometers in thickness in order to support the relief of the fully scarred body. The earth presents no evidence of similar scarring (either in topography or crustal structure) by those earth-fragments that fell back after the original catastrophe. Upholders of the impact theory have satisfactorily explained this fact by the much more prolonged liquidity of the planet at surface, a condition forbidding permanent scarring. The earth-fragment hypothesis here proposed tends to support their contention.

The diameters of the walled plains like Clavius, Ptolemy, Plato, and Grimaldi range from 100 to 300 kilometers; those of the mountain-rings, from 25 to 100 kilometers. But the separation of the two classes from each other and from the still more numerous pits from 5 to 25 kilometers in diameter and curiously distinguished by selenographers under the specialized name, craters, is arbitrary. In view of their transitional relation all three classes are, in the present paper, grouped under the name "craters," the quotation marks implying that they have nothing to do with true volcanic pits. The width of the great pits means that the earth-fragments held to have been responsible for their formation must have had great individual mass, though with mean diameters considerably smaller than those of the respective "craters."

Later we shall note the possibility that a few of the "craters" were due to infall of meteorites. If a meteorite with average velocity struck the moon it would have the same scarring power as one of our earth-fragments with several times its diameter. The infall velocity of the latter would be of the same order as the maximum due to the moon's gravitational pull, namely, about 2.4 kilometers per second or about one-tenth to one-thirtieth of the speeds of "falling stars."

Most of the kinetic energy of the fallen earth-fragment would be converted into heat. If all the energy became heat and were uniformly distributed through the fragment, this would be heated about 2000° C. See discussion by R. S. Woodward, reported by Gilbert (1895: 258). However, there can be no doubt that most of the heat would be concentrated at the interface between fragment and lunar body, according to the principle already described in the case of collision between earth and planetoid. If the mass of an earth-fragment were great enough, much silicate material close to the interface would be melted and, in all probability, volatilized.[10] Thus it seems reasonable to suppose that the initial splashing and other plastic deformation of the lunar crust (including upturn of solid crust-rock around the area of impact) should in many cases have been supplemented by the displacements due to gaseous explosion. The net result would be analogous to the meteoritic deformation at Meteor Crater in Arizona. As Barringer (1924) has so well argued, this analogy eases understanding of leading features of the lunar "craters."

But the Meteor Crater analogy fails for the many lunar "craters" that have broad, flat floors—a form that almost inevitably means former liquidity for the floor material.

Theoretically, massive infalls could give such localized liquidity in more ways than one: (1) by melting at the interface between fragment and moon, with rise of this remelted rock to the surface; or (2) by rise of substratum magma through a relatively thin crust where smashed by the impact; or (3) by local but extensive down-stoping of the broken crust, accompanied by upwelling of the primary substratum melt. That the rise of substratum magma was the most important cause is suggested by the present depth of the floor below the mean level of the lunar surface. For the larger "craters" the difference of level probably averages about 1,000 meters. Explanation of this fact has to take account of the fact that each scarring earth-fragment represented material added to the moon at the "crater" made by its infall. Two different causes for the excessive deepening can be derived from the particular version of the impact theory here offered.

First, we note the vesicularity of the terrestrial fragments when these, which had been more or less saturated with gas at the depths

[10] According to C. Cranz and K. Becker (1921: 449) 95 per cent of the mass of more than one million bullets fired into a sand heap was volatilized—the velocity of each bullet being only about 1,000 meters per second.

and corresponding high pressures of the earth, were torn out and so were released from the high pressure upon them. Some of this vesicularity would persist even after the projectiles were aggregated as a globular nucleus for the moon. In view of the low value of lunar gravity and the relatively feeble power of weight to squeeze out the gas bubbles, we may suppose the surface shell of our satellite to have been, and remain, notably porous. However, the intense pressure at the place of infall, aided by any associated remelting of the crust, would tend to close the pores, with the escape of the gas enclosed in them. In this way the density of the crust at the loci of impact may well have been considerably increased—perhaps by 20 per cent or more. After isostatic adjustment and ultimate freezing of the lava pools the surface of the mended crust at these loci would stand lower than the mean surface of the lunar crust as a whole.

Secondly, there are visible details of form which strongly suggest outward splashing from the region of the "crater" floor, with the addition of much of the displaced rock to the "wreath" rimming the "crater" pit.

Much of the sialic rock forced down in the hot, liquid substratum would be expected to melt in depth, where it would diffuse outward for some distance away from the pit. If, by exception, there were little horizontal movement of that kind, the remelted sial would rise again. It is conceivable that in rare cases this relatively light melt did not rise until the simatic liquid of the respective "crater" floors was frozen. In that case the thin simatic crust might have been pushed up with a more or less complete filling of the pit. In this way can we account for Wargentin, whose flat floor is nearly on a level with the rim?[11]

About half of the larger "craters" contain one or more peaks projecting from the floors and generally not far from the centers of the wide pits. In all cases these central peaks are lower than the corresponding rims. For advocates of the volcanic hypothesis the central peaks are volcanic cones, built up by igneous action some time after much more powerful volcanism had developed rim or "wreath" and flat floor. In support of that view, appeal has been made to a fancied homology with the nested cone-crater relief seen at the tops of terrestrial volcanoes of the Vesuvian type. In the writer's opinion whatever resemblance there may be is merely formal and not genetic. In spite of prolonged search no observer has ever been able to demonstrate a craterlet at the top of any central peak, though Schmidt and a few other selenologists have claimed one in the case of Timocharis. Moreover, the shapes of many of the peaks are not those expected on the volcanic theory.

Most writers who favor some form of the impact theory for the lunar "craters" explain each central peak as the piled-up product of centrifugal, return movements of the moon's plastic-solid material from the "crater" rims—as a phenomenon of recoil. While this explanation seems mechanically sound and supported by laboratory experiments, as well as by the existence of a low but distinct central "peak" on the original floor of the Meteor Crater in Arizona (*fide* Barringer, 1924: 5), our general earth-fragment hypothesis suggests another explanation which may well be supplementary if not competitive. Because of concentration of the heat of impact at the interface between moon and fragment, the temperature at the opposite end of the fragments might, as Gilbert (1895: 272) suggested in principle, fall short of the melting "point" or even short of the point where plasticity under lunar gravity could flatten the whole of the fragment. Retaining considerable porosity and corresponding low density, the residual, unmelted part of the terrestrial fragment would therefore float in the risen sima. That remnant would be kept not far from the center of the "crater" by the strength of the wrecked but more or less coherent crust between the locus of impact and the "crater" rim. Freezing of the risen sima would further guarantee permanent fixation of the residual of the fragment at or near the center of the pit.

Since the terrestrial fragments came from different depths in the planet, the release of pressure upon them greatly varied and the resulting porosity varied from fragment to fragment. We can find here one reason why the heights of the central peaks, regarded as in at least approximately hydrostatic equilibrium with the simatic layer, should differ so much.

On the other hand, it is not hard to conceive that fragments of low porosity and therefore of relatively high density, especially those that fell

[11] Or was Gilbert (1895: 282) nearer the truth when he suggested that Wargentin is a "mountain ring," that is, an old walled plain whose floor was raised by lava flooded in from a neighboring mare? In such case the plateau-like mass would represent an uncompensated load on the lunar crust.

into areas where because of earlier bombardments the lunar crust was specially thin or weak, were completely disintegrated or absorbed by the simatic layer, leaving no visible witness of its former existence as a separate body. In this way we might account for the "craters" that lack central peaks.

To illustrate a fact obvious to every observer with a powerful telescope, Gilbert (1895: 265) measured the "conjugate diameters and through them the ellipticities of 120 [large] craters. In three-fourths of these the ellipticity is less than .1; in eleven-twelfths it is less than .2; in twenty-nine-thirtieths it is less than .3." For some selenologists this close approach to circularity has meant a fatal objection to any form of the impact theory of the lunar "craters." During nearly a century of controversy their argument has run: since many infalls would have to be in directions at high angles to the vertical, the corresponding "craters" in large proportion should have much greater than even the maximum ellipticity determined by Gilbert. That reasoning, however, has been shown to be fallacious through variously-designed experiments, including those with rifles firing into plastic materials, and through study of the pits made by both "live" and "dud" artillery shells that entered the ground at high angles with the vertical. Barringer (1924: 14) has brought corroborative evidence from the nearly circular Meteor Crater of Arizona where he finds that the great hole was formed by a meteorite plunging at an angle of about 45° with the vertical. In view of all the data bearing on a truly complex problem in mechanics, a problem loudly crying for "second thoughts," it seems clear that the earth-fragment hypothesis gives adequate accounting for the roundness of the lunar "craters."

Ten of the great "craters," including Tycho, Copernicus, Kepler, Aristarchus, Proclus, and Anaxagoras, are centers from which "bright rays" extend to distances of hundreds of kilometers. The origin of the rays has been long sought and several different suggestions offered. Wright (1935: 108) has shown reasons for preferring that one which attributes them to violent explosion. Since similar rays were not developed around the great majority of the "craters," it is clear that the exceptional energy displayed at each center needs special explanation. Eruption of the Vesuvian type, resulting from gas which for some reason had been under exceptionally high tension, is conceivable. Another possibility is to be entertained: unusually violent explosion caused by the infall of relatively small meteorites, striking the moon at their normal velocities—generally more than ten times the velocity enforced merely by the moon's attraction. To this second explanation no *a priori* objection is manifest, but this idea is only supplementary to, and not inconsistent with, the general validity of the earth-fragment hypothesis.

One other characteristic of the "craters" needs consideration. They are numerous in all latitudes, high as well as low. This fact matches expectation if we assume that nearly all the "craters" were formed by the infall of terrestrial fragments. We have seen that when the earth itself exploded, with or without a glancing blow from a planetoid, the liquid fragments were sent out from the center of explosion in all directions. Hence many of the flying masses had trajectories highly inclined to the moon's equatorial plane. When these fragments fell they made scars at high latitudes. The scars at low latitudes were made by fragments having trajectories nearer the plane of the lunar equator. In this way we can understand the pockmarking of our satellite from pole to pole.[12]

The problem of the maria will not be discussed in detail. Gilbert, like some other selenographers, could find no evidence of a genetic distinction between "craters" and maria, and regarded these last as the loci of infall of, and melting by, specially massive bodies (the "moonlets" of his theory). He thought that the moon was solid throughout its history and never included thin crust and liquid substratum. For him this view was a logical deduction from his "moonlet" hypothesis. Shaler (1903: 8 & 15) assigned a volcanic origin to the "craters" but saw in the maria areas of melting by the infall of giant bolides, without the rise of subcrustal lava. The present writer finds more satisfaction in the belief that the flooding lava of the maria was chiefly derived from the vitreous substratum of the young moon, just as in the case of the lava-covered floors of the "craters," and relates the difference in superficial extent to the size of the

[12] Gilbert (1895: 275) sensed the difficulty of correlating his "moonlet" version of the impact theory with the abundance of "craters" at high latitudes. He met it by assuming that the moon's axis of rotation was not constant, but his suggestion as to a cause for the inconstancy seems quite inadequate.

infallen masses.[13] After the present paper was nearly completed, it was discovered that Baldwin (1942 and 1943) had come to the same conclusion. He too assumes the infallen bodies (which he calls "meteorites"), large and small, to have been fragments of the earth, but offers no theory of their disruption from the planet. His explanation of the gigantic striations and groovings of the lunar crust south and southwest of Mare Imbrium (so clearly marked in the Loewy-Puiseux atlas) is practically identical with that offered by Gilbert in 1895.

It is, of course, conceivable that the mare-making, infallen bodies were asteroids or "planetoids" rather than fragments of the earth.[14]

It is noteworthy that the observed variation of albedo over the lunar surface appears to corroborate our general hypothesis of origins. In average the surface reflects about 7 per cent of the sun's light. According to Russell, Dugan, and Stewart (1926: 174), the percentage would rise to perhaps as much as 10 if irregularities were smoothed out. This is greater than the albedo of basalt and smaller than the albedo of obsidian. We recall that, from other evidence, the Wright committee found the surface material to behave optically as if it might be volcanic ash or pumice. A pumiceous or at least highly vesicular character is expected from the terms of the favored hypothesis of the moon's genesis. Moreover, the assumption of a thin sialic layer already differentiated and solidified at the time of bombardment is fortified by the facts recorded about the moon's albedo. Selenographers have adopted a ten-step scale for estimates of light-reflecting power. From Neison's text the present writer has compiled the following table, showing the relative average brightness of wall and floor of many "craters":

Number averaged	Diameter in miles	Brightness of wall	Brightness of floor
51	10–30	6.0	3.6
17	30–50	5.0	3.6
7	50–70	5.3	2.75
3	70–100	5.0	2.3

The maria have about the same brightness as that of the broader "crater" floors.

The table gives quantitative expression to the well recognized fact that the inner slopes of the "crater" walls have a much higher albedo than the floors. The table also suggests that this contrast of wall and floor becomes still more pronounced as the diameter of the "craters" increases. The underlying cause for both rules is reasonably found if we assume, in accordance with our general hypothesis, that the original crust of the moon was largely sialic and that the bulk of the floor material is simatic because derived from a substratum which, during the period of infalls, was liquid and eruptible. Support for the second assumption has already been found; that for the first assumption is contained in the expectation that the inner slope of each "crater" should represent the edge of the crust where upturned by violent impact.

The so-called mountain ranges of the moon were explained by Gilbert as gigantic analogues of the "crater" rims, representing widespread, plastic uplift of the crust around the maria—just as the "crater" rims were for him also the effects of peripheral upturning of the crust where struck by the smaller, "crater"-making missiles. The same principle can be applied in the cases where the mountain uplifts were occasioned, not by the infall of "moonlets" of Gilbert's definition

[13] Is it possible that some "craters" in high latitudes resulted from infalls of moon-fragments sent flying in all directions when the huge masses responsible for the Imbrium and other maria struck the moon? Many of these missiles would have to fall back into the moon, permanently scarring the surface outside the liquid maria, with comparatively few falling into the mare regions after their lava was solidified.

[14] Elger (1895: 12) explains the wide "mountain rings" as walled plains which were "partially overwhelmed by the material of the 'seas.'" It does look as if the "overwhelming" took the form of flooding from the maria when the lava of these was liquid and of low viscosity. Wide-ranging spills over the old, scarred crust would be expected because of the temporary superelevation of the lava surface of a mare by (*a*) the addition of the matter of the fragment to each mare sector, and (*b*) the expanded condition of the highly heated lava of whatever source. With the progressive freezing and hence considerable contraction of the mare lava, accompanied by isostatic readjustment of the catastrophically disturbed figure of the moon, much of the still-liquid lava of the flooded region would flow back to the mare region, leaving behind a relatively smooth veneer of chilled, immobilized lava over the flooded area. The old "crater" depressions would have been greatly shallowed by the permanently-held lava of the flood. The final reliefs in the flooded area should therefore be low, the old walled plains having become mountain rings; smaller "craters" would in general have lost crater form and become comparatively smooth domes, the "laccolithic" domes of Tomkins, and originally low peaks would have lost sharpness, even approaching the shapes of elliptical domes. Many examples of such small reliefs of the last two kinds are to be found in the Carpathian Mountain region and elsewhere.

but by the infall of terrestrial fragments (or perhaps planetoids).[15]

SUMMARY

To be successful any attempt to tell how and when the moon was born must be based on a true idea as to the origin of the solar system—an unsolved problem which is not only outside the scope of laboratory experiment but also, at critical points, beyond mathematical control, the second major aid to scientific progress. Similarly, neither experiment nor mathematical reasoning can enable us to trace with absolute confidence the steps of an imagined derivation of the moon from the earth. Cosmogonists are forced to believe that, if truly a fact, such derivation included catastrophe of a kind that permits neither experimental imitation nor mathematical analysis. There is only one other method left for examining the worth of the catastrophe hypothesis: to develop all promising guesses about a possible cause, with the hope of lighting on one that best explains the facts known about the moon itself, its relation to the earth, and the relation of both to the rest of the solar system. The correlations demand the pyramiding of assumptions. In this paper the assumptions made are numerous and most of them lack strong sanction from cosmogonists.

It is suggested that the fragmentation of the young earth was the product of either internal force or external force or of their combination. According to two closely-related conjectures, the primitive earth, supposed to be liquid at the surface, lost to outer space much of its mass by explosion and that with the loss of mass went much of the original angular momentum, leaving only the respective amounts represented in the existing earth-moon system. According to a third conjecture, a "planetoid," captured because of tangential, slicing, collision with the liquid earth, brought with it so much angular momentum as to ensure its perpetuation as a separate, revolving body—the moon we know. All three guesses led to the conception that initially liquid fragments were exploded out of the planet, well beyond Roche's limit. Many of these were gravitatively aggregated by the pull of master fragment or captured "planetoid" to make the substance of our moon, and the somewhat diminished earth felt a prolonged rain of other earth-fragments, large and small.

With the earth-fragment hypothesis it appears possible to account for: (1) the measured mass and mean density of the moon and the distribution of density within it; (2) its general shape and implied degree of strength; (3) the small deviation of its orbital plane from the earth's equatorial plane at the time when the two bodies were close together; (4) the close similarity between the earth's period of rotation and the period of the moon's revolution, at the same early epoch; (5) topographic features of our satellite which many selenologists have thought to demand a volcanic origin for the larger "craters"; (6) some rare cases of hills so alined as to suggest their upbuilding by comparatively feeble volcanic action; (7) the bright "rays" stretched out from a small number of "craters," like Tycho and Copernicus; (8) both presence and absence of central peaks in the "craters"; (9) the average albedo and range of albedo over the lunar surface; and (10) the polarization-angle and specific heat of the surface material.

Other features of the lunar topography seem also to find reasonable explanation. Among them are: the terracing of some "crater" walls; the local wrinkling of, and degree of roughness of, the surfaces of the maria; the overlapping of "crater" on "crater"; the "crater"-pitting of the maria; the long-puzzling "rills" and so-called "valleys"; the rather rare cliffs typified by the Straight Wall; and the extraordinary whiteness of Aristarchus and other local areas. Discussion of these subsidiary problems would have lengthened this paper beyond intended limits.

If the moon did originate by the disruption of an earth which was liquid at the surface, the terrestrial conditions implied would be such as to aid attack on some principal, insistent, and as yet unanswered questions about the earth itself. Among the items in this formidable list are: the range and distribution of internal temperature, strength, and elasticity; the fundamental conditions for igneous action and for mountain-building; the origin of continents and ocean basins; the state of the iron core; and the supposed deviation of the sealevel figure of our

[15] If the crusting of the moon began when that body was comparatively near the earth, the tides set up in the moon should have been powerful. It seems possible that the tidal currents kept breaking up the new crust and upending and rafting-together the irregular pieces. If this were the case, the relief of the crust, when finally complete, would be extremely rough. Can we thus find partial explanation for the chaotic topography of the Apennines and other "mountain ranges" of the moon?

planet from that of a biaxial ellipsoid in fluid equilibrium.[16]

ACKNOWLEDGMENTS

The writer wishes to express specially hearty thanks to Professor Russell who guided him out of more than one blind alley in the maze of speculation; to Professor Whipple who after reading this paper encouraged the idea that one more geologist might be permitted to guess about the moon; to Professor Shapley who generously arranged for the mailing of printed copies of the paper as one number in the Harvard Observatory Reprint Series; and to Professors Bridgman and Birch for discussion of the thermodynamics of colliding bodies. However, none of these five leaders in earth science should be held responsible for any errors in making speculative assumptions or in the deductive argument.

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[16] After its completion the manuscript of this paper was read by Professor H. N. Russell, who drew the writer's attention to the latest explanation of the solar system including the satellites—namely, the hypothesis of C. F. von Weisäcker as digested in the *Astrophysical Journal* **101**: 249, 1945 and published in full in the *Zeitschrift für Astrophysik* **22**: 319, 1944. In a personal letter Professor Russell wrote: "According to this the planets were formed by material which was close to the sun at the time of its origin, and circulating around it, but had never formed part of it. The opportunities for collision of the type to which you attribute the lunar 'craters' would be great." Professor Russell is of opinion that the Weisäcker hypothesis can well be consonant with the impact theory of the lunar "craters." Thus, even if the "earth-fragment hypothesis" is proved inadmissible, the present paper may still have some value in emphasizing from geological evidence the superior claim of bombardment rather than volcanism as the dominant cause for the molding of the moon's face.

HEROES OF SUMER

A New Heroic Age in World History and Literature

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(Read April 20, 1946)

FROM time to time in the course of the history of civilization, and from place to place, we come upon a social phenomenon known as the Heroic Age. To take only three of the more ancient and better known examples, there is the Teutonic Heroic Age which dominated much of northern Europe from the fourth to the sixth century A.D., the Greek Heroic Age which flourished on the mainland of Greece toward the very end of the second millennium B.C., and finally the Heroic Age of India which probably dates only a century or so later than that of Greece.[1] All three heroic ages reveal a marked and significant resemblance in social structure, governmental organization, religious concepts, and aesthetic expression; it is obvious that they owe their origin and being to very similar social, political, and psychic factors. The Sumerian poem, whose extant text is made available for the first time in the present study, is one of a group of heroic narrative poems which will introduce a new Heroic Age, that of the Sumerians, to world history and literature. Although it probably had its floruit no later than the first quarter of the third millennium B.C., and therefore precedes by more than a millennium and a half even the oldest of the three Indo-European Heroic Ages, that of the Greeks, it follows with remarkable closeness the culture pattern typical for those long known epochs.[2]

The Greek, Indian, and Teutonic Heroic Ages, to judge from the relevant literary records, are essentially barbaric periods which show a number of salient characteristics in common. The political unit consists of a petty kingdom ruled by a king or prince who obtains and holds his rule through military prowess. His mainstay in power consists of the comitatus, a retinue of armed, loyal followers, who are prepared to do his bidding without question, no matter how foolhardy and dangerous the undertaking. There may be an assembly, but it is convened at the ruler's pleasure and serves only in an advisory and confirmatory capacity. The ruling kings and princes of the separate principalities carry on among themselves a lively and at times friendly and even intimate intercourse; they thus tend to develop into what may be termed an international aristocratic caste whose thoughts and acts have little in common with those of their subjects. On the religious side we find our three Indo-European Heroic Ages characterized by a worship of anthropomorphic deities which to a large extent seem to be recognized everywhere throughout the various states and principalities. These gods form organized communities in a specially chosen locality, though in addition each god has a special abode of his own. There are few traces of chthonic or spirit worship; at death the soul travels to some distant locality which is conceived as a universal home and is not reserved for members of any particular community.[3] Some of the heroes are conceived as springing from the gods, but there is no trace of heroic worship or hero cults. All these features common to the Heroic Ages of Greece, India, and Northern Europe, are shared by that of Sumer, as the sketch of the contents of the Sumerian epic material about to follow, will reveal.

But the parallelism between our four Heroic

[1] The statements and summations concerning the Greek, Indian, and Teutonic Heroic Ages here presented are based primarily on the analyses and conclusions of H. Munro Chadwick in his *The Heroic Age* (Cambridge, 1912), and of H. Munro and N. Kershaw Chadwick, in their monumental three-volume work, *The growth of literature* (Cambridge, 1932–1940). For the Heroic Age of India, *cf.* N. K. Sidhanta's *The Heroic Age of India* (London, 1929). It is no insignificant index of the value and reliability of these works to note their effective utilization to give meaning and form to an hitherto practically unknown cultural stage in the history of ancient Mesopotamia.

[2] The implications of the uncovering of the existence of a flourishing Sumerian Heroic Age for the archaeology and history of southern Mesopotamia will be discussed in special study now in preparation, "A new Heroic Age and its archaeological implications."

[3] Note however that in the matter of the heroic conception of an after-life, the notion of a warrior's paradise is characteristic of the Teutonic and Indian peoples, but not of the Sumerians, nor of the Homeric Greeks.

Ages extends even further; indeed it is particularly instructive and revealing on the aesthetic plane, especially in the field of literature. For one of the more notable achievements of all four of our Heroic Ages consisted of the creation of an oral group of heroic narrative tales *in poetic form* which reflect and illuminate the spirit of the age and its temper. Impelled by the thirst for fame and name so characteristic of the ruling caste during the Heroic Age, the bards and minstrels attached to the court were moved to improvise and compose narrative poems or lays celebrating the adventures and achievements of those kings and princes whose experiences lent themselves to imaginative and sympathetic treatment; these epic lays whose object was primarily to provide entertainment at the frequent courtly banquets and feasts were recited no doubt to the accompaniment of the harp, lyre, or lute. Now, obviously enough, none of these early heroic lays have come down to us in their original form, since their first composition took place during the Heroic Age itself, when writing was either altogether unknown, or, if known, was of little concern to the illiterate minstrel. The written epics relating to the Greek, Indian, and Teutonic Heroic Ages, as we have them, date of course from much later days, and consist of highly complex literary redactions in which only a selected number of the earlier lays are imbedded, and these in a highly modified and expanded form. In Sumer there is good reason to believe that at least some of the early heroic lays were first inscribed on clay some five to six hundred years following the close of the Heroic Age, and then only after they had undergone very considerable transformation at the hands of the priests and scribes.[4] However, it is to be carefully noted that the copies of the epic texts which we actually have at present date almost entirely from the first half of the second millennium B.C.[5]

Now, as is well known, the written epics relating to the three Indo-European Heroic Ages show a number of striking similarities in form and content. In the first place, the poems are all concerned primarily with individuals; it is the deeds and exploits of the individual hero which are the prime concern of the poet, not the fate or glory of the state or the community. Moreover, while there is little doubt that some of the experiences and adventures celebrated in the poems have a historical basis, the poet does not hesitate to introduce everywhere certain unhistorical motifs and conventions, such as exaggerated notions of the hero's powers, ominous dreams, and the presence of divine beings. Stylistically the epic poems are found to abound in static epithets, lengthy repetitions, and recurrent formulas, while certain types of descriptions tend to be over-leisurely and unusually detailed. Particularly noteworthy is the fact that all the epics devote very considerable space to speeches. In all these respects the Sumerian heroic poetry follows closely the pattern of the Greek, Indian, and Teutonic epic material.[6] And since it is hardly likely that a literary genre so individual in style and technique as narrative poetry was created and developed independently and at different time intervals in Sumer, Greece, India, and Northern Europe, and since that of the Sumerians is by all odds the oldest of the four, it is perhaps not unreasonable to conclude that it is in Sumer that we may look for the origin of epic poetry as a whole.[7]

[4] For the indications that there was considerable Sumerian written literature in existence in the second half of the third millennium B.C., *cf.* my *Sumerian mythology* (*Mem. Amer. Philos. Soc.* **21**: 18–19, 1944).

[5] That is, if we use the new low chronology of Smith and Albright, *cf. Bull. Amer. Schools Orient. Res.* **88**: 28 ff., 1942, and *Amer. Jour. Arch.* **49**: 18 ff., 1945.

[6] Of the more outstanding differences between the Sumerian epic material and that of the Greeks, Indians, and Teutons, we may note the following: (*a*) The Sumerian epic poems revolving about a given hero consist of individual, disconnected tales of varying length, each of which is restricted to a single episode; there is no attempt to articulate and integrate these episodes into a larger epic unit. This was first achieved by the Accadian poets, particularly in their epic of Gilgamesh, who borrowed, modified, and molded the relatively brief and episodic Sumerian sources; *cf.* "The epic of Gilgamesh and its Sumerian sources," in the *Jour. Amer. Orient. Soc.* **64**: 7–23, 1944. (*b*) There is relatively little characterization and psychological penetration in the Sumerian material; the heroes tend to be broad and more or less undifferentiated types, rather than highly personalized individuals. Moreover the incidents and plot motifs are related in a rather static and highly conventional style; there is little of that expressive, plastic movement which characterizes such poems as the *Iliad* and *Odyssey*. (*c*) Women play no role in the Sumerian epic material, while they have a very prominent part in the Indo-European epics. (*d*) In the matter of technique the Sumerian poets depend for their rhythmic effect solely on the variations in the repetition patterns; they make no use of meter or uniform line which is so characteristic of the Indo-European epics.

[7] It is very interesting to note that one of the two authors of *The growth of literature* (*cf.* note 1) had already come to the conclusion that Mesopotamia was the birthplace of narrative or epic poetry and that it had spread from there in different directions; *cf.* vol. III: 725, note 2. The paper there promised in support of this thesis has, as far as I

Let us turn now to the contents of the extant Sumerian epic poems. At present we can identify nine epic tales varying in length from a little over one hundred to very probably more than five hundred lines. Two of these revolve about the hero Enmerkar; two about the hero Lugalbanda, although in one of these Enmerkar, too, plays a considerable role; five center about the most famous of the three heroes, Gilgamesh. All three are known from the Sumerian king list, a document which like our epic material has been found inscribed on tablets dating from the first half of the second millennium B.C. and which again, as in the case of our epic material, was probably composed in the last quarter of the third millennium B.C.[8] Here, that is in the king list, they are stated to be the second, third, and fifth rulers of the first dynasty of Erech which, according to the Sumerian scribes, followed the first dynasty of Kish which in turn followed immediately upon the flood. But, although all three of our heroes are listed in the same dynasty, all our evidence seems to point to the conclusion that they were actually unrelated to each other.[9]

The first of the two Enmerkar epic tales, to judge from the available texts, probably consisted of over five hundred lines; at present, however, only slightly over four hundred can be accounted for, and of these less than two hundred are well preserved.[10] Obviously, therefore, the following sketch of its contents is quite tentative in character, to be filled out and corrected as new material is uncovered. The action of the poem centers about Enmerkar's successful efforts to obtain submission and allegiance from a "lord" of Aratta[11] who remains unnamed throughout the poem. To achieve his end, Enmerkar wins the favor of the great god Enki with the promise that, if Aratta submits to Erech, he will have the inhabitants of Aratta transport stones from the mountains to build a great shrine for him, and that in numerous other ways he will exalt the god, his shrines, and his decrees. He then dispatches a herald to the "lord" of Aratta with instructions to prevail upon him to recognize Enmerkar as his overlord; this he is to achieve by extolling the latter as the favorite of Enki, and particularly by reciting to him the "spell" of Enki.[12] The herald, after a long journey involving the crossing of the seven mountains, finally arrives at Aratta, and, as instructed, repeats Enmerkar's demands to its "lord." The latter at first refuses since such action would result in a loss of prestige for his goddess Inanna whose protégé he seems to be. But the herald overcomes his reluctance with the promise that his patron deity Inanna will be made queen of the temple Eanna in Erech. Whereupon the "lord" of Aratta is ready to yield. This is not the end of the poem, however. After a considerable break in the text we find the "lord" of Aratta addressing his own herald and instructing him to go to Enmerkar and invite him to visit Aratta. For before actually bowing down to Enmerkar as his overlord, he would first meet him face to face that they might debate the issue between them. And so Enmerkar starts on the long journey, accompanied by a considerable retinue. Before his actual arrival, however, Enmerkar once again dispatches his herald to the "lord" of Aratta with a message which seems to consist of a eulogy of his (Enmerkar's) scepter and rule. The herald returns from Aratta with a reply whose import is obscure. Here the text breaks off altogether, with the end of the poem not yet in sight.

The second Enmerkar tale is also concerned with the submission of a "lord" of Aratta to Enmerkar.[13] However, in this poem it is not Enmerkar who makes the first demands on his rival, the "lord" of Aratta, but rather the latter who first issues the challenge which leads to his own discomfiture. Moreover, since throughout our second Enmerkar poem the "lord" of Aratta is referred to by his actual name, Ensukushsiranna, it is not quite certain whether he is to be identified with the "lord" of Aratta who remains unnamed throughout the first Enmerkar poem. As for the available contents of this second Enmerkar tale—at present we have only approximately one hundred well preserved lines at the very beginning of the poem, and very probably some twenty-five well-preserved lines toward the end—they run as follows:

know, not yet appeared; it probably rests largely on the significant fact that the Accadian epic of Gilgamesh (*cf.* under (*a*) in the preceding note) was current all over the Near East in the second millennium B.C. Needless to say, the Sumerian epic material now being made available to the scholar tends to confirm the correctness of this view.

[8] *Cf.* SS (= Supplementary Study of the *Bull. Amer. Schools of Orient. Res.*) No. 3 (now in press), note 3*c*.

[9] *Cf.* SS No. 3, note 3*d*.

[10] *Cf.* SS No. 3, note 3*e*.

[11] For the location of Aratta, *cf. Bull. Amer. Schools Orient. Res.* **96**: 26, note 32, 1944.

[12] For the available text of this spell and its significance for the Sumerian concept of man's golden age, *cf. Jour. Amer. Orient. Soc.* **63**: 191–194, 1943.

[13] *Cf.* SS No. 3, note 3*i*.

Ensukushsiranna, the "lord" of Aratta, having decided to issue a challenge to Enmerkar, the lord of Erech and Kullab, dispatched a herald to him with a demand that the latter submit to his overlordship and "carry the basket for him." If he does so, the herald is to continue—the riddle-like phrases are largely obscure—he will be allowed to dwell with the goddess Inanna and lie with her on a fruitful couch; also he may eat of the kurku-bird with the other ishakku's who have recognized Ensukushsiranna as suzerain. The herald delivers his message to Enmerkar who promptly returns the challenge and contemptuously rejects the promised rewards. Upon hearing this, Ensukushsiranna gathers his council and informs them of Enmerkar's insolent attitude. The rest of the poem is practically entirely destroyed except probably for the very end of the poem where, for some unknown reason, Ensukushsiranna is only too ready to take second place to Enmerkar whom he extolls as the beloved of Inanna and as a great lord who knows no rival.

We turn now to the two epic tales in which the hero Lugalbanda plays the leading role. The first, which may be entitled "Lugalbanda and Enmerkar," is a poem of more than four hundred lines, the great majority of which are excellently preserved.[14] Nevertheless, in spite of the relatively few breaks in the text, the sense of many passages is far from clear, and the following sketch of the more intelligible parts of its contents, based on numerous repeated efforts in the course of the past several years to get at the meaning of the poem, must still be considered highly tentative in character. Lugalbanda, perhaps because he has set his heart on journeying to the far-distant city Aratta, is determined first to win the friendship of the Zu-bird who decrees the fates and utters the word which none may transgress. While the Zu-bird is away, therefore, he goes to his nest and presents his young with fat, honey, and bread, paints their faces, and places the *shugurra* crown upon their heads. The Zu-bird, upon returning to his nest, is most gratified with this god-like treatment of his young, and proclaims himself as ready to bestow friendship and favor upon whatever god or man had done this gracious deed. Whereupon Lugalbanda steps up to receive his reward. Accordingly, the Zu-bird, in a highly eulogistic passage replete with blessings, bids him go head high probably to Aratta. Upon Lugalbanda's request, he decrees for him a favorable journey, and adds some pertinent advice which he is to repeat to no one, not even his closest followers. The Zu-bird now reenters his nest, while Lugalbanda returns to his friends and informs them of his imminent journey. They try to dissuade him; it is a journey from which none return since it involves the crossing of high mountains as well as the dreaded river of Kur. However, Lugalbanda is adamant, and eagerly awaits his opportunity. Now in Erech, Lugalbanda's lord, Enmerkar, the son of the sun-god, Utu, is in great distress. For many years past the Semitic Martu have been ravaging both Sumer and Accad. Now they are laying siege to Erech itself. Enmerkar finds that he must get through a call for help to his sister, the goddess Inanna of Aratta. But try as he will, he can find no one to undertake the dangerous journey to Aratta to deliver his message. This, then, seems to be Lugalbanda's moment. He steps up to his king and bravely volunteers for the task; moreover upon Enmerkar's insistence, he swears that he will make the journey all alone, unaccompanied by any of his followers. After receiving from Enmerkar the exact words of his message to Inanna of Aratta, Lugalbanda hastens to his friends and followers and informs them of his imminent journey. Again they try to dissuade him, but to no avail. He takes up his weapons, crosses the seven mountains that reach from one end of Anshan to the other, and finally arrives with joyful step at his destination. There, in Aratta, he is given a warm welcome by Inanna. Upon her query as to what brought him all alone from Erech to Aratta, Lugalbanda repeats verbatim Enmerkar's message and call for help. Inanna's answer, which marks the end of our poem, is most obscure; it seems to involve a river and its rather unusual fish which Enmerkar is perhaps to catch; also certain water-vessels which he is to fashion, and finally workers of metal and stone whom he is to settle in his city. But just how all this will remove the threat of the Martu from Sumer and Accad, or lift the siege from Erech, is far from clear.

The second Lugalbanda tale, which may be tentatively entitled "Lugalbanda and Mt. Hurrum," probably also ran well over four hundred lines; at present, however, with both the beginning and end of the poem missing, we can account for some three hundred and fifty lines of text of which about half are in excellent condition.[15]

[14] *Cf.* SS No. 3, note 3*k*.

[15] *Cf.* SS No. 3, note 3*v*.

Its available contents, as far as they can be reconstructed from the fragmentary and difficult text, may be tentatively sketched as follows: In the course of a journey from Kullab of Erech to the far distant Aratta, Lugalbanda and his followers arrive at Mt. Hurrum. There Lugalbanda falls ill. His companions, believing that he is soon to die, decide to proceed without him, planning to pick up his dead body upon their return from Aratta, and to carry it back to Kullab. To take care of his immediate wants, however, they leave with him a considerable quantity of food, water, and strong drink, as well as his weapons. Alone, ill, and forsaken, Lugalbanda utters a prayer to the sun-god, Utu, who sees to it that his health is restored by means of the "food of life," and the "water of life." Upon regaining his health, Lugalbanda seems to wander all alone over the highland steppe, living by hunting its wild life and gathering its uncultivated plants. Once, falling asleep, he dreams that he is commanded, perhaps by the sun-god, Utu, to take up his weapons, hunt and kill a wild bull, and present its fat to the rising Utu; also to slaughter a kid and pour out its blood in a ditch, and its fat on the plain. Upon awaking, Lugalbanda does exactly as bidden. In addition, he prepares food and strong drink for An, Enlil, Enki, and Ninhursag, the four leading deities of the Sumerian pantheon. The approximately last hundred lines of the extant text seem to contain a eulogy of seven heavenly lights who help Nanna, the moon-god, Utu, the sun-god, and Inanna, the planet Venus, to give light to the cosmos.

So much for the Enmerkar and Lugalbanda epic material now available. Turning to the most renowned of our trio, the hero Gilgamesh, we can at present identify five epic tales concerned with his adventures and achievements. The texts of two of these, "Gilgamesh and the Bull of Heaven," and "The Death of Gilgamesh," are in a very fragmentary condition; one, "Gilgamesh and Agga of Kish," consists of one hundred and fifteen lines almost perfectly preserved, although its text presents as yet so many difficulties to the translator that much of its meaning still eludes us; the fourth, "Gilgamesh and the Nether World," is a well preserved poem of over two hundred and fifty lines whose introductory passage is particularly significant for the analysis of the Sumerian cosmogonic concepts; the fifth, "Gilgamesh and the Land of the Living," is the epic tale whose entire available text, its first one hundred and seventy-four lines, is presented in this study.[16]

First, then, "Gilgamesh and the Bull of Heaven"; its fragmentary contents, poorly preserved as they are, may be sketched as follows: Inanna, the goddess of love and war, the Sumerian counterpart of the Semitic Ishtar, makes love proposals to the hero Gilgamesh upon whom she is prepared to shower gifts and favors without stint. But Gilgamesh spurns her offers. Whereupon Inanna turns to An, the heaven god, and asks him to present her with the bull of heaven. An at first refuses, but Inanna threatens to take the matter up with all the great gods of the universe. Terrified, An grants her request. Inanna then sends the bull of heaven down against Erech where it proceeds to ravage the city. From here on, the available text which concludes with an address by Enkidu, Gilgamesh's loyal follower and constant companion, to Gilgamesh, becomes unintelligible. The end of the poem, which described no doubt Gilgamesh's victorious struggle with the bull of heaven, is missing altogether.

From the meager extant portion of our second Gilgamesh tale, "The Death of Gilgamesh," only the following contents are recognizable. Gilgamesh, who is seeking immortality, is informed that eternal life is not for him; kingship, prominence, heroism in battle—all these have been decreed for him, but not immortality. Follows the death of Gilgamesh and a long poetic description of the ensuing mourning. After a break of unknown size, we find that Gilgamesh's spirit has probably descended to the nether world to become its king. Here he first presents gifts and offerings to the numerous deities and priests of the nether world for his family and retinue—his wives, children, musicians, chief valet, and attendants. Our poem concludes with a special tribute to the glory and memory of Gilgamesh.

Our third Gilgamesh epic tale, "Gilgamesh and Agga of Kish," with its small but well-nigh perfectly preserved text, is of no little historical and political interest; its contents run approximately as follows: Agga, king of Kish, who according to our poem had at one time been a

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[16] For the scientific edition of this text, including autograph copies of the unpublished material, transliteration, and commentary, *cf.* the forthcoming SS No. 3. For the scientific edition of "The death of Gilgamesh," *cf. Bull. Amer. Schools Orient. Res.* **94**: 2–12, 1944. For an earlier sketch of the Sumerian Gilgamesh material as a whole, *cf. Jour. Amer. Orient. Soc.* **64**: 7–23, 1944.

satellite of Gilgamesh, has now become powerful enough to demand that Erech become subservient to Kish. He therefore sends heralds to Gilgamesh with words to that effect. The latter gathers a council of the elders of Erech who, at the urging of Gilgamesh, commit themselves to take up arms rather than to submit to "the house of Kish." Not yet satisfied, Gilgamesh convokes a second council, this time of all the fighting men of Erech, and repeats his entreaties not to submit to "the house of Kish." This council, too, solemnly resolves to fight rather than yield; moreover it pronounces Gilgamesh as the king and hero of their city. In spite of their brave words and heroic resolutions, however, the people of Erech are terrified by the thought of Agga's approach. Only Gilgamesh, though sadly troubled by the rather cowardly reactions of the Erechites, remains confident; he ends up an address to his faithful follower Enkidu with the lines:

When he (Agga) shall have come, my great fear will overwhelm him,
His judgment will be confounded, his counsel will be dissipated.

In a very short time, however, Agga seems to have succeeded in seizing the outskirts of the city, and the Erechites were dumbfounded. Gilgamesh then addresses the heroes of Erech, and asks for a volunteer to go before Agga. He finds one in Birhurturri who seems convinced that he can confound the judgment and counsel of the king of Kish. No sooner does Birhurturri pass through the gate, however, than he seems to be seized, beaten, and brought before Agga. He begins to address Agga, but, before he has finished, another hero—his name is only partly preserved—ascends the walls of Erech, perhaps to observe what is going on. Follows a conversation between Agga and Birhurturri whose meaning it is as yet impossible to penetrate although the text is in perfect condition. It is reasonably clear, however, that Birhurturri fails to come to terms with Agga, and once again he is beaten by Agga's men. Gilgamesh himself then ascends the walls of Erech. The Erechites, young and old, are now overcome with fright, while the fighting men clutch their weapons. Whereupon Enkidu goes out through the gate and seems to persuade Agga to withdraw his forces and leave Erech in peace. Gilgamesh then thanks Agga whom he describes as his "overseer," "supervisor," and "captain of the host," for sparing his life. Moreover he pronounces Agga as the king and hero of Erech in the identical words which the Erechite council had used when honoring Gilgamesh with the very same titles.

Our fourth Gilgamesh poem begins with what may be described as an introduction of twenty-seven lines whose contents have nothing to do with the story of the poem; their cosmogonic contents merely serve as a preface to it. The story itself runs as follows: Once upon a time a huluppu-tree, perhaps a willow, planted on the bank of the Euphrates and nurtured by its waters, was attacked violently by the South Wind and flooded by the waters of the Euphrates. The goddess Inanna, walking by, takes the tree in her hand and brings it to her city Erech where she plants it in her holy garden. There she tends it most carefully. For, when the tree grows big, she plans to make of its wood a chair for herself and a couch.

Years pass; the tree matures and grows big. But Inanna finds herself unable to cut down the tree. For at its base the snake who "knows no charm" has built its nest. In its crown the Zu-bird has placed its young. In its middle Lilith has built her house. And so Inanna, the light-hearted and ever joyful maid, sheds bitter tears. As the dawn breaks, and her brother, the sun-god Utu, comes forth from his sleeping chamber, she repeats to him tearfully all that has befallen her huluppu-tree. Thereupon Gilgamesh chivalrously comes to her aid. He dons his armor weighing fifty minas, and with his ax of the road, seven talents and seven minas in weight, he slays the snake who "knows no charm" at the base of the tree. Seeing which, the Zu-bird flees with its young to the mountain, while Lilith tears down her house and flees to the desolate places. Gilgamesh and the men of Erech who accompanied him now cut down the tree and give it to Inanna for her chair and couch. Either Gilgamesh or Inanna then fashions of the base of the tree a *pukku*, probably a "drum," and of its crown, a *mikku*, probably a "drumstick." Follows a passage of twelve lines which describes Gilgamesh's activity in Erech with this *pukku* and *mikku*, with this "drum" and "drumstick." Despite the fact that the text is in perfect condition, it is still impossible to penetrate its meaning. It is not impossible, however, that it describes in some detail certain overbearing and tyrranical acts which brought woe to the inhabitants of Erech. When the story becomes intelligible once again, it continues with the

statement that, "because of the outcry of the young maidens," the *pukku* and the *mikku* fell into the nether world. Gilgamesh puts in his hand as well as his foot to retrieve them, but is unable to reach them. And so he seats himself at the gate of the nether world and laments:

"O my *pukku*, O my *mikku*,
My *pukku* whose *lustiness* was irresistable,
My *mikku* whose *pulsations could not be drowned out*,
In those days *when* verily my *pukku* was with me in the house of the carpenter,
(*When*) verily the wife of the carpenter was with me like the mother who gave birth to me,
(*When*) verily the daughter of the carpenter was with me *like* my younger sister,
My *pukku*, who will bring it up from the nether world,
My *mikku*, who will bring it up from the 'face' of the nether world?"

His servant Enkidu thereupon volunteers to descend to the nether world and bring them up for him, saying:

"O my master, why dost thou cry, why is they heart sick?
Thy *pukku*, lo, I will now bring it up from the nether world,
Thy *mikku*, I will bring it up from the 'face' of the nether world."

Hearing his servant's generous offer, Gilgamesh warns him of a number of the nether world tabus which he is to guard against; the passage reads:

Gilgamesh says to Enkidu:
"If now thou wilt descend to the nether world,
A word I speak to thee, take my word,
Instruction I offer thee, take my instruction.
Do not put on clean clothes,
Lest like an enemy *they will mark thee;*
Do not anoint thyself with the good oil of the *buru*-vessel,
Lest at its smell they will crowd about thee.

Do not throw the throw-stick in the nether world,
Lest they who were struck by the throw-stick will surround thee;
Do not carry a staff in thy hand,
Lest the shades will flutter all about thee.

Do not put sandals on thy feet,
In the nether world make no cry;
Kiss not thy beloved wife,
Strike not thy hated wife,
Kiss not thy beloved son,
Strike not thy hated son.
Lest the outcry of Kur will seize thee;
(*The outcry*) *to* her who is lying, *to* her who is lying,
To the mother of Ninazu who is lying,
Whose holy *body* no garment covers,
Whose holy breast no cloth wraps."

But Enkidu heeds not the instructions of his master and commits all those very acts against which Gilgamesh has warned him. And so he is seized by Kur and is unable to reascend to the earth. Thereupon Gilgamesh proceeds to Nippur and weeps before Enlil:

"O father Enlil, my *pukku* fell into the nether world,
My *mikku* fell into the 'face' of the nether world;
I sent Enkidu to bring them up, Kur has seized him.
Namtar has not seized him, Asig has not seized him,
Kur has seized him.
Nergal's ambusher, who spares no one, has not seized him,
Kur has seized him.
In battle, *the place of manliness*, he has not fallen,
Kur has seized him."

But Enlil refuses to stand by Gilgamesh who then proceeds to Eridu and repeats his plea before Enki. The latter orders the sun-god, Utu, to open a hole in the nether world and to allow the shade of Enkidu to ascend to the earth. Utu does as bidden, and the shade of Enkidu appears before Gilgamesh. Master and servant embrace, and Gilgamesh questions Enkidu about what he saw in the nether world. The first seven questions concern the treatment in the nether world of those who were fathers of from one to seven sons respectively. The remaining text of our poem is poorly preserved, but we still have parts of the Gilgamesh-Enkidu colloquy concerning the treatment in the nether world of the palace servant, of the birth-giving woman, of him who falls in battle, of him whose shade has no one to care for it, and of him whose body lies unburied in the plain.

Turning now to the fifth and last of our Gilgamesh poems, the one whose full available text is about to follow, we find its contents to run as follows: The "lord" Gilgamesh, realizing that, like all mortals, he too must die sooner or later, is determined at least to raise up a name for himself before he meets his destined end. He therefore sets his heart on journeying to the far distant land of the living, also known as a cedar land, with the probable intention of felling its cedars and bringing them to Erech. He informs his servant Enkidu of his proposed undertaking, and the latter advises him first to ac-

quaint the sun-god, Utu, with his plan, for it is Utu who has charge of the cedar land. Acting upon his advice, Gilgamesh brings offerings to Utu and pleads for his support of the contemplated journey to the land of the living. Utu at first seems rather skeptical of Gilgamesh's qualifications. But Gilgamesh only repeats his plea in more persuasive language. Utu takes pity on him and decides to help him probably by immobilizing in some way the seven vicious demons personifying those destructive weather phenomena that might menace Gilgamesh in the course of his journey across the mountains situated between Erech and the land of the living. Overjoyed, Gilgamesh gathers fifty volunteers from Erech, unattached men who have neither "house" nor "mother" and who are ready to follow him wherever he goes and to do whatever he does. After having weapons of bronze and wood prepared for himself and his companions, they cross with the help of Utu the seven mountains lying between Erech and the land of the living. Just what happens immediately upon crossing the last of the seven mountains is not clear since the relevant passage is poorly preserved. When the text becomes intelligible again, we find that Gilgamesh has fallen into a heavy sleep from which he is awakened only after considerable time and effort. Thoroughly aroused by this unexpected delay he swears by his mother Ninsun and by his father Lugalbanda that he will enter the land of the living and brook no interference from its guardian, be he man or god. Enkidu pleads with him to turn back, for it is Huwawa who guards the cedars, a monster whose destructive attack none may withstand. But Gilgamesh will have none of this caution. Convinced that with Enkidu's help no harm will fall to either of them, he bids him put away fear and go forward with him. Spying from his cedar house, however, is the monster Huwawa who seems to make frantic but vain efforts to drive off Gilgamesh and his adventurous band. Following a break of some lines, we learn that after cutting down seven trees Gilgamesh had probably come to Huwawa's inner chamber. Strangely enough, at the very first, and seemingly very light, attack on the part of Gilgamesh, Huwawa is overcome with fright, and begs for mercy and protection. Gilgamesh would like to act the generous victor, and in riddle-like phrases suggests to Enkidu that Huwawa be set free. But Enkidu, fearful of the consequences, advises against such unwise action. Following Huwawa's indignant criticism of Enkidu's ungenerous attitude, our two heroes seem to bring Huwawa before the great gods Enlil and Ninlil. So ends the extant portion of our poem, consisting of one hundred and seventy-four lines. At the moment there is no way of judging its full length, but it may well have run on for several hundred lines more.

The preceding paragraph sketches the plot and action of our epic tale "Gilgamesh and the Land of the Living," in prosaic and literal language which utterly fails to convey those qualities and characteristics that mark this composition as one of the finest of Sumerian poetic creations. It will, therefore, be advisable to present a brief summation of our poem's aesthetic relevance. In the first place, its motivating theme, man's anxiety about death and its sublimation in the notion of an immortal name, has a universal significance which lends it high poetic coloring. On the technical side, our poet makes use of uncommonly varied groups of repetition and parallelism patterns whose total rhythmic effect is in full consonance with the poignant mood of the poem's theme. Similarly, from the point of view of content and substance, the poet is careful to select those essential details of the underlying incidents and ideas whose composite effect is to create the heroic tone and superhuman atmosphere which characterize our epic tale. It is this superb blending of its three fundamental ingredients, the significant motivating theme, the effective rhythmic technique, and the imaginative selection of contextual detail, which stamps our composition as a great poem, one which must have made a profound emotional and aesthetic appeal to its credulous and highly sympathetic audience. Indeed, even the modern reader whose mind and temper can no longer accept the rather immature ideas and child-like concepts underlying the far-fetched and incredible episodes, will not remain wholly unmoved by this epic tale, which, like all true poetry, consists essentially of rhythmic language that stirs the imagination. Following, then, is a literal rendering of the available text of the poem "Gilgamesh and the Land of the Living":[17]

[17] Italics indicate doubtful translations. Words between parentheses are not in the Sumerian text but are added for purposes of clarification. Words between brackets are broken away and lost from the original, and are supplied by the author. Words between quotation marks represent literal translations of Sumerian words whose fuller implications are too uncertain to permit a more idiomatic rendering.

The lord, toward the land of the living set his mind,
The lord Gilgamesh, toward the land of the living set his mind,
He says to his servant Enkidu:
"O Enkidu, *not yet have the brick and stamp* brought forth *the fated end;*
I would enter the 'land,' I would set up my name,
In its places where the names (of the gods) have been raised up,
I would raise up my name,
In its places where the names have not been raised up,
I would raise up the names of the gods.

His servant Enkidu answers him:
"O my master, if thou wouldst enter the 'land,' inform Utu,
Inform Utu, the hero Utu—
The 'land,' it is Utu's charge,
The . . . cedar land, it is the hero Utu's charge—inform Utu."
Gilgamesh laid his hands on an all-white kid,
A *brown* kid, an offering, he pressed to his breast,
In his hand he placed the silver staff of his . . .,
He says to Utu of heaven:
"O Utu, I would enter the 'land,' be thou my ally
I would enter the . . . cedar land, be thou my ally."

Utu of heaven answers:
". . . verily thou art, but what art thou to the 'land'?"

[Gilgamesh answers him]:
"O Utu, a word I would speak to thee, to my word thy ear!
. . . I would speak to thee, give ear to it.
In my city man dies, oppressed is the heart,
Man perishes, heavy is the heart,
I *climbed* the wall,
Saw the dead bodies *floating on* the river,
As for me, I too, will be served thus; verily 'tis so.
Man, the tallest, cannot reach to heaven,
Man, the widest, cannot cover the earth,
Not (*yet*) *have brick and stamp* brought forth *the fated end,*
I would enter the 'land,' I would set up my name,
In its places where the names have been raised up,
I would raise up my name,
In its places where the names have not been raised up,
I would raise up the names of the gods."

Utu accepted his tears as an offering,
Like a man of mercy, he showed him mercy.

The seven heroes, the sons of one mother,
The first a . . . that . . . ,
The second, a viper that . . . ,
The third a dragon that . . . ,
The fourth, a *scorching fire* that . . . ,
The fifth, a *raging* snake that *turns the heart,* that . . . ,
The sixth, a destructive deluge that *floods* the . . . in the *land,*
The seventh, the speeding . . . [*lightning*] which cannot be [*turned back*],
These seven . . . ,
He (i. e. Utu) brings into the . . . of the mountains.

Who felled the cedar, *acted joyfully,*
The "lord" Gilgamesh *acted joyfully,*
In his city, as one man, *he* . . . ,
As two companions, *he* . . . :
"Who has a house, to his house! Who has a mother, to his mother!
[L]et single males who would do as I (do), fifty, stand by my side."

Who had a house, to his house! Who had a mother, to his mother!
Single males who would do as he (did), fifty, stood at his side.
To the house of the smiths he directed his step,
The . . . , the . . . ax, the "might of heroism," he caused to be cast there.
To the . . . garden of the plain he [directed] his step
The . . . tree, the *willow,* the *apple-tree,* the *box-tree,* the . . .-[tree], he *felled* there,
The "sons" of his city who accompanied him [*placed them*] in their hands.
The first, a . . . that . . . ,
Hav[*ing been brought*] in the . . . of the mountains,
The first mountain they cross, *he comes not* [*upon*] *his* . . . ;
Upon their crossing the seventh mountain,
. . . he did not *wander about,*
[The lord Gil]gamesh *fells* the cedar.

. . . *to* Gilgamesh,
. . . Gilgamesh . . . *brought,*
. . . *stretched out,*
. . . like . . . *seized,*
. . . set up for [hi]m,
[The "sons" of his city] who accompanied him,
. . . .
. . . *it is* a dream, . . . it is a sleep,
. . . silence . . .

He touches him, he rises not,
He speaks to him, he answers not:
"Who art lying, who art lying,

O Gilgamesh, 'lord,' son of Kullab, how long wilt thou lie!
The 'land' has become dark, the shadows have spread over it,
Dusk has [*brought forth*] its light,
Utu has gone with lifted head to the bosom of his mother Ningal,
O Gilgamesh, how long wilt thou lie!
Let not the 'sons' of thy city [who] have accompanied thee,
Stand *alongside of thee* at the foot of the mountain,
Let not thy mother who gave birth to thee be *driven off* to the 'square' of the city."

He gave heed,
With his "word of heroism" he [covered himself] like a garment
His garment of thirty shekels which *he carried in his hand*, he . . . on his breast,
Like a bull he stood on the "great earth,"
He put *his* mouth to the ground, *his teeth shook:*
"By the life of (the goddess) Ninsun, my mother who gave birth to me, of pure Lugalbanda, my father,
May *I be as one who sits to be wondered at on the knee* of Ninsun, my mother who gave birth to me."
A second time, moreover, he says to *him:*
"By the life of Ninsun, my mother who gave birth to me, of pure Lugalbanda, my father,
Until I will have . . . that 'man,' if he be a man,
(Until) I will have . . . him, if he be a god,
My step directed to the 'land,' I shall not direct to the city."

The *faithful* servant *pleaded*, . . . life,
He answers his master:
"O my master, thou who hast not seen that 'man,' are not terror-stricken,
I who have seen that 'man,' am terror-stricken.
The hero (i. e. Huwawa) his *teeth* are the *teeth* of a dragon,
His face is the face of a lion,
His . . . is the onrushing flood-water,
From his forehead which devours trees and reeds none escape.
O my master, journey thou to the land, I will journey to the *city*,
I will *tell* thy mother of thy *glory*, let her shout,
I will tell her of thy *ensuing* death, (*let her*) shed bitter tears."

105*a* [Gilgamesh answers his servant Enkidu]:
"*For me another* will not die, the *loaded* boat will not sink,
The three-ply cloth will not be cut,
The . . . will not be overwhelmed,
House *and* hut, fire *will* not destroy,
Do thou *help* me (and) I will *help* thee, what *can happen to us?*
After it had sunk, after it had sunk,
After the Magan-boat had sunk,
After the boat, the 'might *of* Magilum' had sunk
In the . . . , the boat of living creatures *are seated those who come out of the womb.*
Come, let us go forward, we will cast eyes upon him,
If we go forward,
(And) there be fear, (and) there be fear, turn it back,
(And) there be terror, (and) there be terror, turn it back,
. . . thy . . . , come, let us go forward."

Who is . . . is not at peace,
Huwawa, moreover, . . . his cedar house.
He fastened his eye upon him, the eye of death,
He *shook* his head at him, waved his head at him,
He *shouted* at him, . . .
Who are . . . men . . . not like. . . ,
Gilgamesh . . . ,
. . . .
. . . . Break of approximately 6 lines
"By the life [of Ninsun], my mother who gave birth to me, [of pure Lugalbanda, my father],
In the 'land' verily *I* know thy dwelling,
My little weak . . . , verily *I* have brought into the 'land' for thee as . . . ,
. . . in thy . . . I would *enter.*"

He himself uprooted the first for him,
The "sons" of his city who accompanied him,
Cut down its crown, bundle it,
Lay it at the foot of the mountain.
After *he himself* had *finished off* the seventh for him, he approached *his chamber*,
He . . . the "snake of the wine-quay" *in his wall*,
Like one pressing a kiss he slapped his cheek.

Huwawa, *his teeth shook*,
. . . his hand trembled:
". . . a word I would say to thee,
. . . [a mother] who gave birth to me I know not, my father who raised me I know not,
The highland (Hurrum) gave birth to me, *thou wilt* raise *me.*"

Gilgamesh swore by the life of heaven, life of the earth, life of the nether world,
Took him *by* the hand (saying): "*Do not prostrate thyself.*"
Then did the heart of Gilgamesh take pity on the . . . ,
He says to his servant Enkidu:
"O Enkidu, let the caught bird go (back) to its place,

Let the caught man return to the bosom of his mother."
Enkidu answers Gilgamesh:
"The tallest who has no judgment,
Namtar (Fate) will devour, Namtar who knows *no distinctions.*
(If) the caught bird goes (back) to its place,
(If) the caught man returns to the bosom of his mother,
Thou wilt not return to the city of the mother who gave birth to thee."
Huwawa says to Enkidu:
"Against me, O Enkidu, thou hast spoken evil to him,
O hired man *who* . . . the food, *who* stands next to the . . . *of* the rival, thou hast spoken evil to him."
When he had thus spoken,
They decree his fate,
They seated him in skin and linen,
They made him enter before Enlil and Ninlil.
Enlil brought forth his palace servant from the sea,
And Ninlil brought forth the . . .
When Enlil and Ninlil . . . :
"Why thus . . . ?
Let him come forth, let him . . . ,
. . . ."

THE COLONIAL IMPULSE

An Analysis of the "Promotion" Literature of Colonization

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1. THE KINDS OF "PROMOTION" LITERATURE

THE drive to persuade settlers to emigrate to the New World left as its record the so-called "promotion literature" which accompanied English colonization in North America. This literature is not simple. It exhibits a wide variety of appeals, which varied from decade to decade and which occasionally contradicted each other. This changing emphasis was a function sometimes of international politics, sometimes of real or fancied economic and social alterations in the British Isles. To this aspect of promotion literature the attention of historians has frequently been directed,[1] but perhaps less attention has been paid to the social and occupational distribution of the arguments in the propaganda. These varied with the class and status of the group to which the appeal was made. If arguments were sometimes contradictory, the contradiction was inevitable. Reasons which might move statesmen were not necessarily identical with those advanced by an explorer who wanted backing for some hazardous enterprise; and the interests of noble or mercantile investors in a joint-stock colonization scheme were not the same as those of the actual colonists. Ministers talked about the plantations from one point of view; military strategists from another; politicians from a third. The theories of an arm-chair writer, even if he were as well informed as the elder Hakluyt, differed *toto caelo* from the practical needs set forth by hard-bitten heads of actual settlements, like Captain John Smith. Moreover, whatever the power of the printed or the written word might be among the middle and upper classes, it must not be forgotten that the majority of Englishmen could not read—a fact which calls for severe scrutiny of certain hasty inferences drawn concerning this propaganda. Finally, it is important to remember that one of the principal purposes of "promotion literature" was to combat the flood of slander and malicious gossip about the colonies, of which almost every important writer complains.[2]

[1] See for representative discussions P. A. Bruce, *Economic History of Virginia in the Seventeenth Century*, I, chap. i, New York, 1907, and George L. Beer, The Early English Colonial Movement, *Pol. Sci. Quarterly* **23**: 75–94; 242–258, 1908.

[2] Gossip was a real menace to both the Irish and the American plantations. There seems to be no reason, however, to suppose that it was the product of organized anti-colonial groups or that it was especially associated with the theater. The point would not be worth making, were it not for the importance which has been attached to a passage in William Crashaw's celebrated sermon of 1609: "As for *Plaiers* (pardon me right Honourable and beloued, for wronging this place and your patience with so base a subiect,) they play with *Princes* and *Potentates*, *Magistrates* and *Ministers*, nay with *God* and *Religion*, and all *holy things:* nothing that is good, excellent or holy can escape them: how then can this *action?* But this may suffice, that they are *Players:* they abuse *Virginea*, but they are but *Players:* they disgrace it: true, but they are but *Players*, and they haue *played* with better things, and such as for which, if they speedily repent not, I dare say, vengeance waites for them. . . . But why are the *Players* enemies to this Plantation and doe abuse it? I will tell you the causes: First, for that they are so multiplied here, that one cannot liue by another, and they see that wee send of all trades to *Virginea*, but will send no *Players*, which if wee would doe, they that remaine would gaine the more at home. Secondly, as the *diuell* hates vs, because wee purpose not to suffer *Heathens*, and the *Pope* because we haue vowed to tolerate no *Papists:* so doe the *Players*, because wee resolue to suffer no *Idle persons in Virginea*, which course if it were taken in *England*, they know they might turne to new occupations." *A Sermon Preached in London before . . . his Maiesties Counsell for . . . Virginea, Febr. 11. 1609*, London, 1610, sig. H4. Taken in conjunction with the celebrated scenes in *Eastward Ho*, this passage has sometimes been construed as evidence of anti-colonial propaganda in the Jacobean theater. Aside from the danger of trusting clerical evidence concerning the Jacobean stage, it does not appear that the colonial theme received an undue amount of attention from the dramatists, and in fact the passages cited by Robert R. Cawley,

Promotion literature falls into several categories which it is useful to distinguish.[3] (1) The most impressive genre is the formal treatise on colonization, of which there were in general two sorts: treatises which, anticipating settlement, theorized from inference or from the example of other nations about the character of the proposed colony; and treatises which drew general conclusions from English experience, once it had begun. The first type is mostly a sixteenth-century product, the second mainly comes from the epoch of the Stuarts. The one is well represented by the admirable expository prose of Gilbert's *Discourse* (1576) and Hakluyt's *Discourse of Western Planting* (1584), both addressed directly to government.[4] The most illustrious example of the later type is probably Bacon's *Of Plantations* (1625). (2) One may associate with the formal treatise the general prefaces or other introductory matter to collections of voyages or even to works dealing with a specific expedition or colony. Of this kind of essay the prefaces to the various volumes of the second edition of the *Principal Navigations* are notable; and the introductory pages of *The Golden Fleece* (1626) and of John Hammond's *Leah and Rachel* (1656) show how perfunctory the form became.[5]

The great bulk of "promotion literature," however, is related to some particular enterprise. Propaganda for such a plantation might begin with a third type of writing, (3) the official request to government for a patent or with the patent itself, both published in order to persuade "adventurers" to invest and settlers to emigrate.[6] Accompanying the official documents or published separately might be (4) the report of the exploratory voyage or voyages, which usually stressed the economic plenitude of the new settlement, the excellence of its climate, the healthiness of its situation, and the gentleness of the natives.[7] Such a report might be merely the log of the voyage, or it might be, as in the classical instance of Hariot's *Virginia* (1588), a formal exposition of the potential benefits of the country as well. Once settlement had begun, the proprietor or the supporting company authorized, directly or indirectly, (5) the circulation of material likely to induce emigration, such as the "Coppie of a letter from Virginia, dated 22d of June, 1607, from the Councell their to the Councell of Virginia here in England," written to

> quicken those good spirritts w^{ch} haue alreadie bestowed themselues heere, and to put life into such dead understandings or beleefs that muste firste see and feele the wombe of o^{r} labour and this land before they will entertaine anie good hope of vs or of the land. . . .[8]

Such letters had at once an official sanction and a personal tang. Pamphlets like Robert Johnson's *Nova Britannia*, dedicated to Sir Thomas Smith of the Council for Virginia, were printed at least at the instigation of the company,[9] and one like *A Trve Declaration of the estate of the Colonie in Virginia* (1610) was a direct official utterance intended, as the title page indicates, to be a "confutation of such scandalous reports as haue tended to the disgrace of so worthy an en-

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who has made the most extensive study of the New World as a theme for dramatists, reveal no special hostility towards the plantations. See his *The Voyagers and Elizabethan Drama*, 273–295, Boston, 1938. And on the general subject see also his *Unpathed Waters*, Princeton, 1940, especially pp. 117–170.

[3] So far as the New World is concerned, the characteristics of several of these categories had already been established by Elizabethan propaganda for Irish settlement.

[4] *A discourse written by Sir Humphrey Gilbert Knight, to prove a passage by the Northwest to Cathaia, and the East Indies*, most conveniently found in Hakluyt's *Principal Navigations* (Hakluyt Soc.) VII: 158–203: *A particuler discourse concerning the greate necessitie and manifolde comodyties that are like to growe to this Realme of Englande by the Westerne discoueries lately attempted, written in the yere 1584. by Richarde Hackluyt of Oxforde, at the requeste of the righte worshipfull Mr. Walter Rayhly* . . . in *Documentary History of the State of Maine* II, ed. Charles Deane, Cambridge, 1877.

[5] *The Golden Fleece Diuided into three Parts, Under which are discouered the Errours of Religion, the Vices and Decayes of the Kingdome, and lastly the wayes to get wealth . . . By Orpheius Iunior* . . . London, 1626. This is by William Vaughan. *Leah and Rachel* is most easily consulted in C. C. Hall, *Narratives of Early Maryland, 1633–1684*, 281–308, New York, 1910.

[6] Brown's *Genesis of the United States* reprints items of this sort. See, *e. g.*, "Reasons for raising a fund for the support of a Colony at Virginia," from the Lansdowne MSS, I: 40–41.

[7] George Peckham's *A true Report of the late discoveries, and possession taken in the right of the Crowne of England of the Newfound Lands, By that valiant and worthy Gentleman, Sir Humfrey Gilbert Knight* (*Principal Navigations, ed. cit.*, VIII: 89–131) is typical. Note the *apologia:* "By occasion of this Historie, I drewe my selfe into a more deepe consideration of this late undertaken Voyage, whether it were as well pleasing to almightie God, as profitable to men: as lawfull, as it seemed honourable: as well gratefull to the Savages, as gainefull to the Christians. And upon mature deliberation I found the action to be honest and profitable, and therefore allowable . . ."(p. 93).

[8] Reprinted in Edward D. Neill, *Early Settlement of Virginia and Virginiola*. . . , 10–11, Minneapolis, 1878.

[9] Reprinted in Peter Force, *Tracts* I, no. 6.

terprise." [10] Among publications directly emanating from authority must also be reckoned (6) the official laws and the regulations concerning the acquirement of land, both being intended to assure the settler of the morality and good order of the enterprise.[11] Perhaps, however, the best known form of company-inspired propaganda was (7) the official sermon, such as Robert Gray or William Crashaw preached for the Virginia company. The occasion of these was some such event as "the said Lord Generall His leaue taking of England his Natiue Countrey, and departure for Virginia." [12] Such discourses appealed to the serious middle class, and by the atmosphere of religious respectability which they threw over colonization helped to combat wild talk in the taverns and the evil tales of returning seamen.[13] Sometimes the official origins of a particular sermon or pamphlet were disguised, as in the case of *A Relation of The successefull beginnings of the Lord Baltemore's Plantation in Mary-Land* (1634), which, purporting to be compounded from "certaine Letters written from thence, by some of the Aduenturers to their friends in *England*," failed to reveal that it was put together by Cecilius Calvert, Lord Baltimore, from correspondence sent him by Leonard and George Calvert.[14]

Emanating neither directly from the company or the proprietor nor from any other official source, another variety of "promotion literature" is what may be called (8) the personal report by an interested observer. The writer may or may not have been a colonist, just as he may or may not have had a financial stake in the welfare of the plantation but, because he reports as an individual, the note of personal experience gives special force to his narrative. Thus the fascinating *A true reportory of the wracke, and redemption of Sir Thomas Gates Knight; upon, and from the Ilands of the Bermudas: his comming to Virginia, and the estate of that Colonie then, and after, under the government of the Lord La Warre* by William Strachey [15] contains much material which a company might conceivably have wished to suppress, though the general drift of the narrative favors a strong colonial establishment. Edward Winslow's *Good News from New England: or a true Relation of things very remarkable at the Plantation of Plymouth* . . . (1624) [16] is both a personal narrative and a contribution to the general theory of colonization, written "to discourage such as, with too great lightness," desire to emigrate. And of course many of the writings of Captain John Smith fall into this general category.

Although the style and manner of "promotion literature" vary from document to document and decade to decade, certain general observations can be made regarding its literary quality. It is at once a literature of action and a literature of persuasion directed to a non-literary audience, and, being such, it was cut off from the vagaries of Euphuism or the tortuousness of Jacobean experimental prose.[17] Its style usually remains

[10] This was "published by aduise and direction of the Councell of Virginia." See Force, *Tracts* III, no. 1.

[11] Thus, in order, as the prefatory address remarks, to check malice and to refute the charge that "we liued there lawlesse, without obedience to our Countrey, or obseruance of Religion to God," William Strachey published in 1612 the *Lawes Diuine, Morall and Martiall* of "Virginea Britannia" (Force, *Tracts* III, no. 2), obviously an authorized work; and thus Richard Whitbourne brought out his *A Discovrse and Discovery of Nevv-Fovnd-Land, With many reasons to prooue how worthy and beneficiall a Plantation may there be made* . . . London, 1620, containing practical regulations for getting to North America and for settling there.

[12] Gray's sermon is *A Good Speed to Virginia*, London, 1609, dedicated to the Virginia Company. On Crashaw see note 2, above.

[13] ". . . some bad natures will not sticke to slander the Countrey, that will slovenly spit at all things, especially in company where they can find none to contradict them. Who though they were scarse euer 10 miles from *Iames* Town, or at the most but at the falles; yet holding it a great disgrace that amongst so much action, their actions were nothing, exclaime of all things, though they never adventured to knowe any thing; nor euer did any thing but devoure the fruits of other mens labours. Being for the most part of such tender educations and small experience in martiall accidents: because they found not English cities, nor such faire houses, nor at their owne wishes any of their accustomed dainties, with feather beds and downe pillowes, Tavernes and alehouses in every breathing place, neither such plenty of gold and siluer and dissolute liberty as they expected, had little or no care of anything but to pamper their bellies, to fly away with our Pinnaces, or procure their means to returne for England." John Smith, *A Map of Virginia*, 1612, in *Travels and Works*, ed. Arber-Bradley, I: 82–83.

[14] In Shea, *Early Southern Tracts* (no. 1), Baltimore, 1865. See the introduction. The pamphlet served as the basis for the *Relation of Maryland*, London, 1635. The letters have great charm.

[15] Most accessible in *Hakluytus Posthumus or Purchas His Pilgrimes* XIX: 5–72, Glasgow, 1906.

[16] Reprinted in Edward Arber, *The Story of the Pilgrim Fathers*, 509–598, London and Boston, 1897.

[17] There are of course exceptions. Thus William Vaughan's *Golden Fleece* is occasionally mincing in manner, as is Sir Robert Gordon's *Encouragements, For such as shall have intention to bee Vnder-takers in the new plantation of Cape Briton* (1625). In general, however, one has to await the writing of *The Simple Cobbler of Agawam* for a

within the central tradition of English prose, the intent being to tell a plain tale simply or to present argument in its clearest form. Being a literature of action, it is also in the main removed from the introspective and brooding quality of certain Elizabethan and Jacobean traditions. However impressive the appeal to morality, religion, patriotism, or profit, the documents exhibit no curiosity about individual psychology. Even in New England one finds no subjective Hamlets, and in Virginia the weak complainings of Edward Maria Wingfield startle one because of the contrast between his sick and lonely vanity and the rugged strength of his companions.[18] For this is a masculine literature. No woman recorded her impressions of the hardships of the sea, the beauty and horror of the woods, the "civilitie" of the Indians or the hardships of building a colonial home at Roanoke or Jamestown. It is not until deep into the seventeenth century that feminine comment on American topics begins to appear.[19] "Promotion literature" likewise mirrors a world without childhood. And finally, except for the allure of land and riches which it holds out to all comers, it is a literature which one would search in vain to find out what the indentured servant thought and felt. "Promotion literature" seldom or never falls below the level of the middle class, to which it was in the main addressed. This audience conditioned the quality of its stylistic appeal.

2. THE APPEAL TO *VIRTÙ*

What are the chief themes of "promotion literature"? If it be true, in Williamson's words, that the first thirty years of the seventeenth century represent "an outburst of colonizing energy which renders the Elizabethan achievements insignificant in comparison," [1] an Elizabethan atmosphere envelopes the dawn of American settlement-making. It is therefore to be expected that among the principal appeals made to the nobility and the gentry is the appeal to Renaissance *virtù*—to that combination of a well-rounded activity with the promise of immortal fame which is in part heroic and in part polite. The heroic note was early sounded, the promise of fame was early given. Explorers and colonizers sometimes wrote (or were written about) as if they were eternizing their own courage. Confronted by the perils of the Northwest Passage, Frobisher, according to George Best,

> determined and resolved with himselfe to go make full proofe thereof, and to accomplish or bring true certificate of the truth, or els never to returne againe, knowing this to be the only thing of the world that was left yet undone, whereby a notable minde might be made famous and fortunate.[2]

To discover the Northwest Passage, wrote Ramusius in his account of Sebastian Cabot,

> would be the most glorious, and of most importance of all other that can be imagined to make his name great, and fame immortall, to all ages to come, farre more then can be done by any of all these great troubles and warres which dayly are used in Europe among the miserable Christian people.[3]

Only he could succeed as a colonial leader, wrote Edward Hayes, whose "motives be derived from a vertuous & heroycall minde," and like many another commentator Hayes attributed the many failures to unworthy ideals—colonizing is "an action doubtlesse not to be intermedled with base purposes." [4] Sir George Peckham urged his readers to "follow the example of our right vertuous predecessors of renowmed memorie, and leave unto our posteritie a divine memoriall of so godly an enterprise," and even after his multitudinous disappointments Sir Ferdinando Gorges could write: "what can be more pleasing to a generous nature then to be excercised in doing

fantast to describe North America. For the Gordon document see *Royal Letters, Charters, and Tracts, relating to the Colonization of New Scotland*, ed. David Laing, Edinburgh, Bannatyne Club Publications no. 114, 1867.

[18] See "A Discourse of Virginia" (1608) printed from the Lambeth Library MSS. by Charles Deane in *Archaeologia Americana* **4**: 67–103, 1860. Richard II might conceivably have uttered such sentiments as: "I never turned my face from daunger, or hidd my handes from labour; so watchfull a sentinel stood myself to myself. I know wel, a troope of errors continually beseege men's actions; some of them ceased on by malice, some by ignorance. I doo not hoodwinck my carriage in my self love, but freely and humblie submit it to your grave censures" (p. 76).

[19] Excepting always some of the early Puritan letters.

[1] J. A. Williamson, *A Short History of British Expansion*, 156, London, 1927.

[2] Hakluyt, *Principal Navigations* VII: 277–278. *Cf.* Richard Chancellor, searching for the Northeast Passage and told by certain Scotsmen of the terrors of an Arctic winter, who, "'persuading himself that a man of valour could not commit a more dishonourable part than, for fear of danger, to avoid and shun great attempts . . . was nothing at all changed or discouraged with the speeches and words of the Scots, remaining stedfast and immutable in his first resolution: determining either to bring that to pass which was first intended, or else to die the death.'" Quoted by Williamson, p. 89.

[3] Baptista Ramusius in his preface to the thirde volume of the Navigations, *Principal Navigations* VII: 150.

[4] *Principal Navigations* VIII: 36, 39.

publique good. Especially when his labour and industry tends to the private good and reputation of himselfe and posterity and what monument so durable, as erecting of Houses, Villages, and Townes. . . ." [5]

These were general observations, but the aura of Renaissance greatness settled around particular individuals as well. The earliest such case is perhaps that of Sir Humphrey Gilbert who, before Drake, was *par excellence* the model of colonial "magnanimity." Of him George Gascoigne wrote that one must

> highly prayse the noble minde and courage of the Authour [i. e., Gilbert], who more respectinge the publique profit that might ensue by this *Discoverie*, then the delicate life of a Courtier, well countenanced and favoured both by his Prince and all the Nobilitie, had prepared his owne bodie to abide the malice of the windes and waves, and was even ready to have perfourmed the voyage in proper person, if he had not beene by her Majestie otherwise commanded. . . .

This compliment was accompanied by a "prophetical sonnet":

> Men praise *Columbus* for the passing skil
> Which he declared, in *Cosmographie*,
> And nam'd him first (as yet we cal him stil)
> The *2. Neptune*, dubd by dignity.
> *Americus Vesputius*, for his paine,
> *Neptune* the *3.* ful worthely was named,
> And *Magellanus*, by good right did gaine,
> *Neptune* the 4. ful fitly to be famed.
> But al those three, and al the world beside,
> Discovered not, a thing of more emprice,
> Then in this booke, is learnedly descride.
> By vertue of my worthie friendes device.
> Yf such successe, to him (as them) then fall,
> *Neptune* the *5.* we justly may him call.[6]

When Gilbert sailed in 1578 Thomas Churchyard, having dreamed of the terrors of the deep, woke into undistinguished rhyme:

> Then wayd I how, immortal Fame
> was more than worldly care,
> And where great mind remaynes
> the bodyes rest is small,
> For Countreys wealth, for priuate gayne
> or glory seeke we all,

and promised to write

> A Booke that to the loftie Skyes,
> your rare renowne shall rayse.[7]

And to Gilbert's fated voyage of 1583 a poet laureate was attached—Stephen Parmenius of Buda, who "adventured in this action, minding to record in the Latin tongue, the gests and things worthy of remembrance, happening in this discovery, to the honor of our nation." [8] The unfinished Latin poem of Parmenius had the curious fortune of being translated into English verse by the father of the Autocrat.[9]

Other explorers and colonial leaders were likewise draped in the glory of Renaissance fame. Having reference to the second voyage to Guiana, Chapman said that Raleigh was one of

> you patrician spirits that refine
> Your flesh to fire, and issue like a flame
> On brave endeavours, knowing that in them
> The tract of heaven in morn-like glory opens.[10]

A pamphlet declared that Hawkins

> returned home the second time, laden with as much wealth and honor, as euer any had done before him, and to this braue heroicall scale of Discouery, had now added diuers noble and spacious Stayres . . . you may see how euen from the infancy of our English trauell, euery man hath had a noble ambition, and most probable assurances of good hope to attaine a height of honour and wealth, which yet rests vnattained. . . . [What is fitter for a king than] the very toppe and Garland of All Heroyicall actions?[11]

[5] *Principal Navigations* VIII: 130; Gorges, *A Briefe Narration of the Originall Undertakings of the Advancement of Plantations Into the parts of America*, London, 1658, in *Sir Ferdinando Gorges and His Province of Maine*, ed. J. P. Baxter, II: 79, Prince Soc., Boston, 1890.

[6] *Prefatory Epistle to A Discourse of a Discoverie for a New Passage to Cataia* and sonnet. See Gascoigne's *Works*, ed. J. W. Cunliffe, II: 562–567, Cambridge, 1910.

[7] *The Entertaynement of the Queenes Maistie into Suffolke and Norffolke* in W. G. Gosling, *The Life of Sir Humphrey Gilbert*, appendix ii, 174, 181, London, 1911. Much of the poem is devoted to sea-sickness, bad food, and other matters customarily beneath the dignity of a courtier, which, however, Gilbert faced.

[8] See Irvin Anthony, *Ralegh and his world*, 73, New York, 1934.

[9] See [Abiel Holmes], *A Memoir of Stephen Parmenius of Buda; with a Latin Poem, Composed by Him, in M. D. LXXXIII. And Now First Translated into English, M. DCCC. IV.* Parmenius called Gilbert "decus immortale BRITTANÆ," prophesied a glorious future for the plantation and a new golden age in America: "Et priscos referunt mores, vitamque sequuntur ITALIÆ antiquæ, et primi rudi temporis ævum" (pp. 10, 13).

[10] *De Guiana, carmen Epicum*, in *Works of George Chapman: Poems and Minor Translations*, with an introduction by Algernon Charles Swinburne, 50–52, London, 1875. See the curious passage which pictures Elizabeth, "Her ears and thoughts in steep amaze erected," blessing Raleigh!

[11] *Newes Of Sr Walter Rauleigh. With The true Description of Gviana: As also a Relation of the excellent Gouernment, and much hope of the prosperity of the Voyage. Sent from a Gentleman of his Fleet . . . From the Riuer of*

Such men, said Michael Drayton, are "our Argonauts," whose "great Mindes" descry "farre Regions," and in the nineteenth song of the endless *Poly-Olbion* he rhymed the immortality of Frobisher, Davis, Gilbert, Drake, Raleigh, Amadas, Barlow, Grenville, and others:

> Nor should Fame speake her low'dst, Of *Lane*, shee could not lie,
> Who in *Virginia* left, with th' English Colony,
> Himselfe so bravely bare, amongst our people there,
> That him they onely lov'd, when others they did feare.
> And from those Barbarous, brute, and wild *Virginians* wan
> Such reverence, as in him there had been more then man.

And the better known "To the Virginian Voyage" is a paean to Renaissance *virtù:*

> You brave Heroique Minds,
> Worthy your Countries Name,
> That Honour still pursue,
> Go and subdue,
> Whilst loyt'ring Hinds
> Lurke here at home, with shame.
> . . . . . .
> And as there Plenty growes
> Of Lawrell every where,
> APOLLO'S Sacred tree,
> You may it see,
> A Poets Browes
> To crowne, that may sing there.[12]

Thus the literary men praised "the famous ranke of our Sea-searching men."

Classical examples were to be emulated, or were surpassed:

> These and the like Heroicall intents and attempts of our Princes, our Nobilitie, our Clergie, & our Chivalry, I have in the first place exposed and set foorth to the view of this age, with the same intention that the old Romans set up in wax in their palaces the Statuas or images of their worthy ancestors. . . . Not that the sayd wax or portraiture had any . . . force at all in it selfe, but that by the remembring of their woorthy actes, that flame was kindled in their noble breasts, and could never be quenched, untill such time as their owne valure had equalled the fame and glory of their progenitors.[13]

So wrote the great historian of the English voyages. Sir Humphrey Gilbert was but one among many who held up the "experience of Alexander the great, in the time of his conquest of India" for emulation. In 1609 Robert Johnson concluded his *Nova Britannia* by saying:

> . . . it would be my griefe and sorrow, to be exempted from the company of so many honourable minded men, and from this enterprise, tending to so many good endes, and then which, I truely thinke this day, there is not a worke of more excellent hope vnder the Sun, and farre excelling (all circumstances wayed) those Noble deedes of *Alexander*, *Hercules*, and those heathen Monarks, for which they were deemed Gods among their posterity.[14]

And when in 1612 Englishmen seemed to be failing in their support of Virginia, Johnson reminded them of

> that worthie Ramane [*sic*] Scipio, preserver of his Countrie, which when all the Romanes in that sudden feare of Hannibals approach threw off their arms to take themselves to flight, drew out his sword and staied their running out, and ruine of the citie.[15]

John White appealed to yet another example from the Punic wars:

> It is reported that when *Annibal* lay before *Rome*, it discouraged him much in his hopes of taking the Citty, that at the same instant there marched out of the Citty at contrary gates under their colours an Armie of souldiers towards the sea, to be shipped & sent over for a supply into *Spaine;* for it argued the *Romans* feared him not, that durst spare a supplie of men to a Countrie so farre distant when the enemie lay at the gates. . . .

Let the English imitate the Romans and send out colonies.[16] Crashaw implored his audience to remember, from the example of the companions of Romulus and Remus, that "a harder course of

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Caliana, on the Coast of Guiana . . . London, 1618, in Force, *Tracts* III, no. 4: 5–6, 11, 12. Cavendish was not satisfied to say with Hercules, *ne plus ultra*, and Guiana "shall so darken all the actions either of *Cortez* or *Pescaro*, that nothing but pouerty will appeare in their deeds, neyther *Mexico* nor *Peru* bee worthy to be compared with it, and what Prince soeuer shall possesse it, shall bee Lord of more gold, of a more beautifull Empire, and of more Citties and people than either the King of Spaine or the great Turke" (p. 12). As a measure of achievement this resembles Marlowe's *Tamburlaine:* "Shall Tamburlaine extend his puissant arm . . . . Even from Persepolis to Mexico," (III: 3, 1345, 1353).

[12] *Works* II and IV, ed. J. W. Hebel, Oxford, 1932–1933. *Cf.* J. Q. Adams, Michael Drayton's *To the Virginia* [*sic*] *Voyage*, *Mod. Lang. Notes* **33**: 405–408, 1918.

[13] *Epistle Dedicatorie* to vol. II of the 2nd ed., *Principal Navigations* I: lxv–lxvi.

[14] *Nova Britannia: Offering Most Excellent fruites by Planting in Virginia* . . . London, 1609; reprinted in Force, *Tracts* I, no. 6: 27–28. *Cf. A Trve Declaration*, 1610, in *do.* III, no. 1: 21.

[15] *The New Life of Virginea*, London, 1612, reprinted in Force, *Tracts* I, no. 7: 24.

[16] *The Planters Plea*, 1630, Force, *Tracts* II, no. 3: 31.

life, wanting pleasures," "a strict forme of gouernement," and "seuere discipline" were essential to the creation of a new nation.[17] In his *Historie of Travaile into Virginia Britannia* William Strachey desired the English to meditate on antique examples of *virtù:*

It is read that Themistocles hearing of the great victory that Melciades [Miltiades] has obteyned on the playne of Marathon, said, that that report would not lett him take any rest; and Julius Caesar wept at the sight of Alexander's image (who had at the yeares of twenty-four obtayned the name of Great), and cryed out: "Am not I miserable, that have done nothinge worthy of memory, and yet this prince at these yeares hath executed so many notable thinges?" Shall these, for the smoake of momentary glory, breake out thus passionate and forward? and shall not we, for the glory of our God be as affectionate [i. e., eager] and ambitious?[18]

And a more generalized appeal to ancient example appears in such passages as these:

Wee reade that the Bees whe' they grow to be too many in their own hiues at home, are wont to bee led out by their Captaines to swarme abroad and seeke themselues a new dwelling place. If the examples of the Grecians and Cathaginians of olde time and the practise of our age may not mooue vs, yet let vs learne wisdome of these smal weake and vnreasonable creatures.[19]

Consider: What were the beginnings and endings of the Monarkies of the *Chaldeans*, the *Syrians*, the *Grecians*, and *Romanes*, but this one rule; What was it they would not doe, for the good of the commonwealth, or their Mother-citie? For example: *Rome*, What made her such a Monarchesse, but onely the aduentures of her youth, not in riots at home; but in dangers abroade? and the iustice and iudgement out of their experience, when they grewe aged. What was their ruine and hurt, but this: The excesse of idlenesse, the fondnesse of Parents, the want of experience in Magistrates, the admiration of their vndeserued honours, the contempt of true merit, their vniust iealosies, their politicke incredulities, their hypocriticall seeming goodnesse, and their deeds of secret lewdnesse? finally, in fine, growing onely formall temporists, all that their predecessors got in many years, they lost in few daies. Those by their pain and vertues became Lords of the world; they by their ease and vices became slaues to their seruants. . . . Then, who would liue at home idly (or thinke in himselfe any worth to liue) onely to eate, drink, and sleepe, and so die?[20]

Had not this violence and this injury bene offred to us by the Romanes (as the warlike Scots did the same, likewise, in Caledonia, unto the Picts), even by Julius Cæsar himself, then by the emperour Claudius, who was therefore called Britannicus, and his captains, Aulus Plautius and Vespatian (who tooke in the Isle of Wight); and lastly, by the first lieutenant sent hither, Ostorius Scapula (as writes Tacitus in the lief of Agricola), who reduced the conquered partes of our barbarous iland into provinces, and established in them colonies of old souldiers; building castells and townes, and in every corner teaching us even to knowe the powerfull discourse of divine reason (which makes us only men, and distinguisheth us from beasts, amongst whome we lived as naked and as beastly as they). We might yet have lyved overgrowen satyres, rude and untutred, wandring in the woodes, dwelling in caves, and hunting for our dynners, as the wild beasts in the forrests for their praye, prostetuting our daughters to straungers, sacrificing our childrene to idolls, nay, eating our owne childrene, as did the Scots in those daies. . . .[21]

Therefore let the English bring the Indians into "ciuilitie."

To the sanction of classical history was added the sanction of religious fame. "Whole Decads," wrote Sir Robert Gordon, "are filled with discoveries there, and volumes with their actions of plantation"; and of the "renowned *Drake*," the "memorable *Candisch*," Raleigh, Amadas, White, Grenville and others he prophesied that "all [Christian] after-ages" would "eternize" their courage as a "shining brightnesse." [22] The preacher Robert Gray said in 1609 that

The name, memorie and actions of those men doe only liue in the records of eternitie, which haue emploied their best endeuours in such vertuous and honourable enterprises, as haue aduanced the glorie of God, and inlarged the glorie and wealth of their countrie;

[17] Crashaw, *op. cit.*, sig. E4 verso and F. *Cf.* a similar appeal to the example of Hannibal, *Neves Of Sr. Walter Rauleigh*, in Force, *Tracts* III, no. 4: 4.

[18] *The Historie of Travaile into Virginia Britannia . . . by William Strachey, Gent., The First Secretary of the Colony*, ed. R. H. Major, 14, London, Hakluyt Society, 1849.

[19] Hakluyt, *Divers Voyages*, 9, Hakluyt Soc., 1850. This is from the *Epistle Dedicatorie* to the "Right Wor, shipfull and Most Vertuous Gentleman Master Phillip Sydney, Esquire."

[20] John Smith, *A Description of New England . . .*, London, 1616, in *Works, ed. cit.*, 209. Smith goes on to cite the warning example of Byzantium, ruined by sloth and bribery. *Cf. A Trve Declaration of the estate of the Colonie in Virginia*, 1610, Force, *Tracts* III, no. 1, especially pp. 15–19.

[21] William Strachey, *The Historie of Travaile into Virginia Britannia*, 17–18.

[22] In his *Encovragements*, 1625, reprinted in Laing, *op. cit.*, the dedicatory epistle.

wherefore the fame of the Virginia Company must last "so long as the Sunne and Moone endureth." [23]

Such language is not mere rhetorical ornamentation. Captain John Smith, to be sure, lamented the presence of incompetent "gentlemen" at Jamestown, but it is easy to become bemused by this famous passage, and in truth, if the colonies were to have leaders, it was felt that they must come from the nobility and the gentry. As Ralph Lane wrote Walsingham in 1585, the colony

> has undertaken with a good company to remain there, resolute rather to lose their lives "than to defer possession" of so noble a kingdom to the Queen, their country, and their noble patron Sir Walter Ralegh. . . .[24]

and this concept of *noblesse oblige* demanded men who could understand the force of Smith's appeal to leadership:

> Such actions haue ever since the worlds beginning beene subiect to such accidents, and every thing of worth is found full of difficulties: but nothing so difficult as to establish a common wealth so farre remote from men and meanes; and where mens mindes are so vntoward as neither do well themselues, nor suffer others.[25]

Only the patriotic magnanimity of the nobles of Rome and, Athens or of the Goths and Vandals, thought "Orpheus Junior," had created colonies in the past, for these leaders

> forsooke their owne habitations, to accompany the meaner sort of people, and to lead them into forraigne Countries, who without their personall presence, would haue staied at home like Drones. . . .[26]

Whatever the harm wrought by idle gentlemen may have been, John Bargrave wrote the Lord Treasurer in 1623 or 1624, after seven years observation of the faults of Jamestown, he would demonstrate "by right reason" that Virginia could be saved, provided means were made available to draw a sufficient number who had good estates, to plant in Virginia and to cause the Virginia planters to plant estates in England (i. e., increase the gentleman class); and he cited Lycurgus, Junius Brutus, and other heroes in his effort to secure eight or ten gentlemen with seven or eight thousand pounds annual revenue to become the heads of colonies in the New World.[27] The direct appeal of *A Relation of Maryland* lies in the initial statement that various "Gentlemen, of good birth and qualitie . . . resolved to adventure their Persons, and a good part of their fortunes with his Lordship, in the pursuite of so noble and (in all likelihood) so advantagious an enterprize." [28] Remembering the position of leadership which the English gentleman of the Renaissance possessed, one finds the promise of fame showered upon colonial worthies excellent propaganda, not mere preposterous rhetoric:

> Though these be gone, and left behinde a name,
> Yet *Smith* is here to Anvile out a peece
> To after Ages, and eternall Fame,
> That we may haue the golden *Iasons* fleece.
>
> He *Vulcan* like did forge a true Plantation,
> And chain'd their Kings, to his immortall glory;
> Restoring peace and plentie to the Nation,
> Regaining honour to this worthy Story.[29]

Smith himself well knew the need of securing capable leaders from the upper classes. Lords and gentlemen, he says,

> haue imployed great paines and large expence in laying the foundation of this State, wherein much hath beene buried vnder ground, yet some thing hath sprung vp, and giuen you a taste of your adventures. Let no difficulties alter your noble intentions . . . [and let] valiant and generous spirits, personall posessors of these new-found Territories . . . banish . . . Cowardise, covetousnes, iealousies, and idlenes.[30]

He could utter propaganda about their usefulness, saying that "30 or 40 of such voluntary Gentlemen would doe more in a day then 100 of the rest that must bee prest to it by compul-

[23] *A Good Speed to Virginia*, London, 1609, the dedication.

[24] *Cal. State Papers Col., 1574–1660*, ed. W. Noel Sainsbury, 3, London, 1860.

[25] *The Proceedings of the English Colonie in Virginia*, in *Works* I: 96.

[26] [William Vaughan], *The Golden Fleece*, pt. iii: 8, London, 1626.

[27] See E. D. Neill, *Virginia Vetusta*, 154–161, Albany, 1885. Bargrave is said to have been the first person to establish a private plantation in Virginia.

[28] Reprinted in C. C. Hall, *Narratives of Early Maryland, 1633–1684*, 70.

[29] John Smith, *Works*, I: 280. See also the complimentary verses on pp. 284 and 288:

> I know not how Desert more great can rise,
> Then out of Danger t'ane for good mens Good;
> Nor who doth better winne th' *Olympian* prize,
> Than he whose Countryes Honor stirres his bloud;
> Private respects haue private expectation,
> Publicke designes, should publish reputation.

[30] *The Generall Historie of Virginia*, *Works* I: 279.

sion," [31] and he could pen a paragraph designed to appeal to Renaissance "magnanimity":

> Who can desire more content, that hath small meanes; or but only his merit to aduance his fortune [i. e., younger sons], then to tread, and plant that ground hee hath purchased by the hazard of his life? If he haue but the taste of virtue and magnanimitie, what to such a minde can bee more pleasant, then planting and building a foundation for his Posteritie, gotte from the rude earth, by Gods blessing and his owne industrie, without preiudice to any? If hee haue any graine of faith or zeale in Religion, what can he doee less hurtfull to any: or more agreeable to God, then to seeke to conuert those poore Saluages to know Christ, and humanitie, whose labors with discretion will triple requite thy charge and paines? What so truely sutes with honour and honestie, as discouering things vnknowne? erecting Townes, peopling Countries, informing the ignorant, reforming things vniust, teaching virtue; and gaine to our Natiue mother-countrie a kingdom to attend her: finde imployment for those that are idle, because they know not what to doe: so farre from wronging any, as to cause Posteritie to remember thee; and remembring thee, euer honour that remembrance with praise?[32]

"Our forefathers," wrote Johnson,

> not looking out in time, lost the prime and fairest proffer of the greatest wealth in the world, and wee taxe their omission for it, yet now it falles out, that wee their children are tryed in the like, there being yet an excellent portion left, and by Diuine providence offered to our choice. . . .
>
> Let the English therefore not imitate those effeminate Romans who clipped the wings of Victory when they set up her statue, but rather let them remember the prophecy of the Sibyl that "before the ende of the world there shall be a discouerie of all Nations." [33]

[31] *The Proceedings of the English Colonie in Virginia, op. cit.* I: 127. This follows upon the famous description of putting the gentlemen at Jamestown to work "so pleasantly as within a weeke, they became Masters; making it their delight to heare the trees thunder as they fell. But the axes so oft blistered their tender fingers, that commonly every third blow had a lowd oath to drowne the eccho: for remedy of which sin, the President devised howe to haue euerie mans oathes numbered; and at night, for every oath to haue a can of water povvred downe his sleeue" (p. 126). The good humor displayed towards men of his own class in this performance has been drowned out by the desperate earnestness with which some historians have discussed the incident. Smith had no desire to frighten potential leaders away.

[32] *A Description of New England*,1616, *Works* I: 208–209. His *New Englands Trials*, 1620, was an appeal to the peers of the realm. *Ibid.*, 247.

[33] *Nova Britannia*, Force, *Tracts* I, no. 6: 26, 22.

3. THE RIGHT TO EMPIRE

By the time Jamestown was founded there were probably very few Englishmen who did not understand that, if England was to survive, Spain must be met and matched in the New World. The literature of colonizing, like the literature of Elizabethan England, is filled with examples of the cruelty of the Spaniards towards the English,[1] their ill-treatment of the Indians,[2] their greed,[3] their treachery,[4] and, what

[1] Among a dozen examples which might be cited see *A discourse written by one Miles Philips Englishman, one of the company put on shoare Northward of Panuco, in the West Indies by M. John Hawkins 1568. conteining many special things of that countrey and of the Spanish government, but specially of their cruelties used to our Englishmen, and amongst the rest to him selfe for the space of 15. or 16. yeres together, until by good and happy meanes he was delivered from their bloody hands, and returned into his owne Countrey. An. 1582* in *Principal Navigations* IX: 398–445.

[2] Not to speak of English versions of Las Casas, one finds such comments as this by Sir Walter Raleigh: ". . . when the poor men and women had seen us, and that we gave them meat, and to every one something or other, which was rare and strange to them, they began to conceive the deceit and purpose of the Spaniards, who indeed (as they confessed) took from them both their wives and daughters daily, and used them for the satisfying of their own lusts, expecially such as they took in this manner by strength." Raleigh also reports the Spaniards' use of torture to compel the Indians to reveal their secrets, and says that "I would rather have lost the sack of one or two towns . . . than to have defaced or endangered the future hope of so many millions, and the great, good, and rich trade which England may be possessed of thereby." *Discovery of Guiana, Works* VIII: 430, 436, 451, Oxford Univ. Press, 1829. See also the interesting passage on the Spanish greed for gold, p. 418.

[3] E. g., the Council in Virginia wrote to the council in England as early as June 22, 1607, expressing apprehension lest the Spaniard "lay his rauenous hands uppon theas gold showing mountains. . . ." Neill, *Virginia and Virginiola*, 11. Or again, the Spaniards, wrote Robert Johnson in 1612, must not imagine the whole world to be theirs, "shouldring out all other nations, accounting themselues Kings and Commanders, not onely in townes and places where they haue planted, but ouer all other partes of *America*, which containe sundrie vast and barbarous Regions . . . they neuer knew, nor did euer sette foote therein." *Nova Britannia*, in Force, *Tracts* I, no. 6: 7. If the Spaniards, wrote Sir William Alexander had but "sincerely, and gratefully . . . bestowed the benefits" God gave them, their colonies would have been perfect, but their greed merely increased the wars among the Christian nations. *The Mapp and Description of New-England*, 6, 1630, in Laing, *op. cit.*, The Spaniards wrote Vaughan, are "like to the Dogge in the Manger, doe want people to plant, and yet they will not permit others to plant." *The Golden Fleece*, part iii: 5, 1626.

[4] "Who hath been so thirsty of our bloud as *Spaine*? And who hath spilled so much as he? Who hath been so long our enemy? And who hath corrupted so many of our

amounted to the same thing from the English point of view, their Catholicism.[5] Arguments directed towards the larger strategy of statesmanship, however, were presumably directed mainly to government or to influential leaders—great lords, captains entrepreneurs, the wealthy, prominent clergymen, and the like. It seems appropriate therefore to turn to the political motives for colonization. Hatred and distrust of Spain, however powerful as emotional forces, did not constitute a policy. How to use colonization as a check on the most powerful country in the world was the problem set before promotion literature.

The theory that an English colonial empire could be built up to balance the empires of other European powers radically altered the whole concept of plantations. In the earlier literature the idea of a settlement meant the seizure of a river-mouth or other excellent harbor as a fortified trading post. The problem of over-running the interior was held in abeyance. Thus the directions furnished by Richard Hakluyt of the Middle Temple for Frobisher's expedition advise a "first Seate" on the seacoast with a view to protecting his vessels, creating a naval base and controlling trade with the interior. An interesting corollary of this theory is the insistence upon cordial relations with the Indians in order that trade may go forward.[6] Earlier attempts at settlement—for example, at Newfoundland—were sometimes intended only to control fishing.[7] By the time of issuing letters patent to Sir Thomas Gates (and others) for Jamestown, however, settlers are instructed to move inland a hundred miles, if they can, and emphasis is laid upon exploring a wide interior area, as the work of John Smith and others demonstrates.[8] More-

Nation as *Spaine?* And that all with the help of gold, which by reason of the neglect of this Designe he doth still enioy, tempting our weak ones, and our false ones withall. Would you finde a Traitor on a suddain? *Balaams Asse* will tell you where, at the *Spanish* Embassadours doore. And when? when they come from Masse, and otherwise. When to? when they Match with us. For his malice is so great, he cannot hide; nor will God (I hope) suffer it." [Thomas Scott], *An Experimentall Discoverie of Spanish Practises or the Counsell of a well-wishing Souldier, for the good of his Prince and State. . . .*, 53, London, 1623. It is interesting to note that nothing touched Edward Maria Wingfield more to the quick than the charge of plotting with the Spaniards: "I confesse I haue alwayes admyred any noble vertue & prowesse, as well in the Spanniards (as in other nations); but naturally I haue alwayes distrusted and disliked their neighborhoode." A Discourse of Virginia, *Archaeologia Americana* **4**: 98, 1860.

[5] Ralph Lane wrote Walsingham from the first Roanoke colony August 12, 1585, that "[I] for myne owne parte, doo finde my selfe better contented to lyve with fysshe for my dayely foode, and water for my dayely dryncke, in the prosecucione of suche ane accione, then oute of the same to lyve in the greateste plenty that the Courte coolde gyve mee: comforted cheefely here unto with an assuerance of her Majesty's gretenes hereby to growe by the Addycione of suche a kingedom as thys ys to the rest of her Domynyones; by meane whereof, lykewyse, the Churche of Chryste thoroughe Chrystendom may, by the mercy of God, in shorte tyme finde a relyfe and freedom from the servytude and tyranny that by Spayene (beynge the swoorde of that Antychryste of Rome and hys secte) the same hath of long tyme beene most myserabelly oppressed with. Not doutyng, in the mercy of God, to bee suffycyently provyded for by him and most assuered by fayethe in Chryste, that, rather then hee wyll sufferre hys ennemyes the Papystes to tryumphe over the overthrowe ether of thys most Chrystyan Accione, or of us hys poore servantes, in the thoroughe famyne of other wantes,—being in a vaste Countrey yett unmannerde, thoughe most apte for yt,—that hee wyll comaunde even the ravennes to feede us." In *ibid.*, 12.

[6] See *Notes framed by M. Richard Hakluyt of the middle Temple Esquire, given to certaine Gentlemen that went with M. Frobisher in his Northwest discoverie, for their directions . . .* in *Principal Navigations, ed. cit.*, VII, 244–250. Like Gilbert's earlier *Discourse*, Hakluyt contemplates only a fortified trading post on the route to India. Hakluyt remarked: "If they shall live without sea traffique, at the first they become naked by want of linnen and woollen, and very miserable by infinite wants . . . and so will they be forced . . . to depart, or else easely they will be consumed by the Spanyards, by the Frenchmen, or by the naturall inhabitants of the countrey, and so the enterprize becomes reprochfull to our Nation. . . ." But if the English could get space only "for the scope of a citie" traffic could go forward, provided that "all humanitie and curtesie and much forebearing of revenge to the Inland people be used. . . ." Frobisher obediently proposed to settle "certaine numbers of chosen souldiers and discreet men" to guard the coast, proposed that "knock-down" forts and houses be taken along, and remarked that many "well minded and forward young Gentlemen of our countrey willingly have offered themselves." He had in mind a settlement of 100–140 mariners. 30 miners, and 30 soldiers. *The Third voyage of Captaine Frobisher, pretended for the discoverie of Cataia, by Meta Incognita, Anno. Do. 1578* in *do.* VII: 320–321.

[7] Thus Anthony Parkhurst wrote in 1578 that if Belle Isle were "peopled and well fortified (as there are stones and things meete for it throughout all Newfound land) wee shall bee lordes of the whole fishing in small time," and hope that the island "in the mouth of the river of Canada should bee inhabited." "A letter written to M. Richard Hakluyt of the Middle Temple, conteining a report of the true state and commodities of Newfoundland, by M. Anthonie Parkhurst Gentleman" in *Principal Navigations, ed. cit.* VIII: 8, 9, For the same reason Captain Charles Leigh writes from Guiana to the Privy Council in 1604 that he has resolved to remain at the mouth of the Wyapoco River with forty men. *Cal. State Papers Col. 1574–1660*, 5.

[8] See the "Instructions given by way of Advice" in Brown, *Genesis* I: 79 ff.

over, the necessity of thinking of colonies in political terms meant that the notion of a plantation as a private enterprise had to be modified, so that in the minds of some theorists, it became the business of the state rather than that of "adventurers," to support the colony.[9]

The example of other nations, and notably of Spain, had its profound effect, as a variety of passages shows. The Spanish and Portuguese empires, wrote Peckham, should

> minister just cause of incouragement to our Countreymen, not to account it so hard and difficult a thing for the subjects of this noble realme of England, to discover, people, plant and possesse the like goodly lands and rich countreys not farre from us . . . [and] not a little animate and encourage us to looke out and adventure abroad, understanding what large Countreys and Islands the Portugals with their small number have within these few yeeres discovered, peopled and planted. . . .

Portugal, he thought, was not bigger than "three shires of England," Spain was no more populous than the realm of Elizabeth.[10] Hakluyt argued that "our true and syncere relligion" ought to spread at least as readily as Iberian Catholicism, and was fearful lest the Spaniards or the French "seize and fortify" before the English got around to it.[11] "When I consider," he wrote in the *Divers Voyages*,

> that there is a time for all men, and see the Portingales time to be out of date, and that the nakednesse of the Spaniards and their long hidden secretes are nowe at length espied, whereby they went about to delude the worlde, I conceiue great hope that the time approcheth and nowe is, that we of England may share and part stakes (if wee will our selues), both with the spaniarde and the Portingale, in part of America and other regions, as yet vndiscouered. And surely if there were in vs that desire to aduance the honour of our countrie which ought to bee in euery good man, wee woulde not all this while haue foreslowne the possessing of these landes, whiche of equitie and right appertaine vnto vs. . . .[12]

If the English suffered disasters, the fact that the Spaniards had overcome similar disasters was turned into an expansionist argument.[13] In sum, for "inlarging their bounds, in truth their [the Spaniards'] praise is duly given, and well deserved," wrote Johnson, "and it may justly serve to stirre us up by all our means to put off . . . reproachfull censures."[14] But the only way to rival Spain was to cease thinking of colonies as mere trading posts and to begin thinking about them in terms of empire. Thus it was that the imperial spirit was born.

Despite occasional "little England" arguments,[15] an expansionist note was sounded in

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[9] The interesting "Reasons or Motives for the raising of a publique stock to be employed for the peopling and discovering of such Countries as may be found most convenient . . . ," printed by Neill in his *Virginia Vetusta*, 28–34 (see also Brown, *Genesis* I: 37–41) reveals the conflict between the private theory and the public theory of colonial support. The fifth reason is: "Private purses are cowld compfortes to adventurers, and have ever been founde fatall to all enterprices hitherto undertaken by the English, by reason of delaies, jelocies, and unwillingness to backe that project which succeeds not at the first attempt." Reasons 7 and 8 are: "It is honorable for a State rather to backe an exploite by publique consent, than by a private monopoly" and "where Collonies are founded for a publique well may continewe in better obedience, and become more industrious, then where private men are absolute signers of a voiage, forasmuch as better men of havier and qualities will engage themselve in a publique service which carieth more reputacon with it, than a private, which is for the most part ignominious in the end, as being presumed to ayme at a lucre, and is subject to emulacion, fraude and envie, and when it is at the greatest hight of fortune can hardly be tolerated by reason of the jelosie of State." Half a century later, John Hammond was to echo this attack on private investment in his analysis of the ills which afflicted Virginia, which, not being settled "at the publique charge," was "maintained by Adventurers, whose avarice and inhumanity, brought in these inconveniences, which to this day brands Virginia. Then were Jayls emptied, youth seduced, infamous women drilled in, the provisions all brought out of England, and that embezzled by the Trustees . . . no civil courts of justice . . . no redresse of grievances, complaints were repaied with stripes, moneys with scoffes, tortures made delights, and in a word all and the worst that tyrany could inflict or act. . . " *Leah and Rachel*, 1656, in Hall, *Narratives of Early Maryland, 1633–1684*, 284–285.

[10] Peckham's *A true Report*, in *Principal Navigations* VIII: 126–127, 129.

[11] *Discourse of Western Planting, ed. cit.*, 9–12; 97–103. He argued that colonies have enriched both Spain and Portugal, "which realmes, beinge of themselves poore and barren have founde suche occasion of employmente, that these many yeres we have not herde scarcely of any pirate of these twoo nations . . ." (p. 36).

[12] *Divers Voyages, ed. cit.*, 8. *Cf.* the *Epistle Dedicatorie* to the second volume of the second edition of the *Principal Navigations* I: lxvi–lxviii, as also the translation of *Laudonniere, do.* VIII: 442–445.

[13] *Cf.* John Smith, *A Map of Virginia*, 1612, *Works* I: 147–148; *A True and Sincere Declaration* in Brown, *Genesis* I: 347.

[14] *The New Life of Virginea*, Force, *Tracts*, I, no. 7: 19. *Cf.* Smith, *A Description of New England*, *Works*, I: 216.

[15] Alarmed (like others) by the decay of shipping, Robert Hitchcock noted in 1580 that too many marine stores had to be imported, but he argued that "I could name the places within this Realme, where there is plentie of Timver," that there was timber enough in Ireland, and that

promotion literature while the economic struggle with Spain fused with the political conflict. If Columbus and Cortes had in their time been laughing stocks, they could now (1583), wrote Peckham, be considered "neither . . . fantasticke nor vainely imagined."

> I doe therefore heartily wish, that seeing it hath pleased almightie God of his infinite mercy, at the length to awake some of our worthey Countrey men out of that drowsie dreame, wherein we have so long slumbered: That wee may now not suffer that to quaile for want of maintenance, which by these valient Gentlemen our Countreymen, is so nobly begun & enterprised.[16]

The queen's grant of Virginia to Raleigh was "for uniting in more perfect league and amitie, of such Countryes, landes, and territories so to be possessed and inhabited as aforesayd with our Realmes of England and Ireland," [17] and other colonial patents ran to the same effect. Promotion literature is filled with the casuistry of imperialism: perhaps Johnson's *Nova Britannia* is as characteristic as any. Directed against the "blind diffidence of our English natures, which laugh to scorne the name of *Virginia*," it argues that "diuine testimonies" require the English to fulfill a manifest destiny

> For the honor of our King, and enlarging of his kingdome, and for preseruation and defence of that small number our friends and countrimen already planted . . .

"Where is our force and auncient vigour?" asked Johnson. "Doth our late reputation sleepe in the dust?" [18] Even the failures of the English were turned into arguments for expansion. Thus the author of *Virginias Verger* wrote of the lost colony at Roanoke that

> their carkasses, the dispersed bones of their and their Countrey mens since murthered carkasses, have taken a mortall immortall possession, and being dead, speake, proclaime and cry, This our earth is truly English, and therefore this Land is justly yours O English.[19]

Listing colonial enterprises since Babel, the author of *A Trve Declaration of the estate of the Colonie in Virginia* (1610) exclaimed:

> Which heroicall actions, haue not beene vndertaken by so mighty states and Princes, vpon triuiall and vulgar motiues, when by these courses that first blessing (of *crescite* and *multiplicamini*, increase and multiplie) hath beene sanctified: the meaner sorte haue beene prouided: the matter of plagues, famine and sedition, hath beene exhausted: the fennes of a state politique were drained: the enemies of their peace were bridles: the reuenues of their treasury were augmented: and the limits of their dominions were enlarged.[20]

Thus to increase British territory seemed to Sir Robert Gordon of Lochinvar a participation in the "mysticall bodie politicke," demanding those "constant resolutions," that "incomparable honour" which the Spanish and Portuguese had displayed.[21]

The vigor with which English writers from Thorne downward denied the right of Spain to the North American continent is equalled only by their insistence upon the prior right of English discovery. "The landes, countries, and territories of this parte of America which we call ours, and by the name of Virginia, or Nova Britannia," wrote Strachey, "being carefully laid out (of purpose) to avoid offence unto certaine boundes, and regions" cannot interfere with Spain.[22] But more characteristic was the argument of Gilbert, Hakluyt, and Strachey himself that British discoverers, beginning with Madoc, had first set foot on the mainland, from which, by their own logic, the Spaniards were to be excluded.[23] Edward Hayes held that God, not permitting the Spanish or the French to colonize North America, had preserved it for the realm of England, Hayes' countrymen being

> now arrived into the time by God prescribed of their vocation, if ever their calling unto the knowledge of God may be expected.[24]

"for Iron there is greate plentie made within this lande." He seems to want home resources developed. *Tudor Economic Documents*, ed. R. H. Tawney and E. Power, III: 249–250, London, 1924.

[16] *A true Report* in *Principal Navigations* VIII: 95, 96.

[17] See *The letters patents, granted . . . to M. Walter Raleigh* in *Principal Navigations* VIII: 292.

[18] In Force, *Tracts* I, no. 6: 10, 14, 6, 8.

[19] *Purchas His Pilgrimes, ed. cit.*, XIX: 228.

[20] Force, *Tracts* III, no. 1: 4.

[21] *Encovragements, For such as shall have intention to bee Vnder-takers in the new plantation of Cape Briton . . .*, Edinburgh, 1625, [Sig. C], in Laing, *op. cit.*

[22] *Historie of Travaile into Virginia Britannia, ed. cit.*, 4.

[23] See, e. g., Peckham's statement about Madoc, *Principal Navigations* VIII: 108, which includes the interesting idea that "Welsh wordes at this day" are spoken by the Indians "as David Ingram . . . reporteth in his relations."

[24] *Principal Navigations* VIII: 38. When the Spaniards tried to push northward, "they proved most unhappy, and were at length discouraged utterly by the hard and lamentable successe of many both religious and valiant in

Even the Indians, by receiving the English kindly, recognized the providential quality of English imperialism.[25] The author of *Virginias Verger* expresses more rhetorically than some of his contemporaries that mingling of defiance of Spain and the expansionist mood which led to the singeing of King Philip's beard:

> Great and glorious Elizabeth! how didst thou contemne the Iberian threates? How didst thou invert, divert, subvert their attempts? How victoriously didst thou evade their invincible Invasion? how didst thou invade the Invaders, at their gates, in their ports? how didst thou meete them in the Atlanticke, pursue them to the South, to the Indian Seas, and round about the World? How did the skie, windes, waves serve to a higher providence in thy deliveries, in thy triumphs? how often were the prodigious Carrikes of the East, and prodigall Vessels of the West, either staid at home for feare, or driven to fort-covert by the way, or costly wafted on their way, or burned in the way, or sunke out of the way, or carried quite away to visite the English shoares, and adorne the Trophees of great and glorious Elizabeth? Rouze up your brave spirits English hearts in loyall subjection to your Royall Soveraign: be ready to offer right, feare not to suffer wrong: seeke the good, and see the goods which Virginia offers.[26]

But it was not alone by the conquest of North American soil that Spain was to be checked. The Spanish navy had to be beaten, and Spanish trade with both the Indies had to be reduced or centered on England. For both these purposes a far-flung colonial establishment seemed necessary. Because, as Johnson wrote, "Experience hath lately taught vs by some of our neighbour Prouinces, how exceedingly it mounts the State of a Commonwealth, to put forth Nauigation . . . into all parts and corners of the world," [27] almost all the writers agreed that the New World was an inexhaustible source of naval supplies. One citation will do as well as twenty:

> And if an Iland needs woodden Wals to secure it against others, to enrich it from others, Virginia offers her service herein, and will looke so much more cheerefully on you, how much more you shall disburthen her in this kind: yea, as England hath wooed and visited Virginia, so herein Virginia will be glad and rejoyce to visit England, in her therebuilt ships, and to dwell here with us in thence-brought Timbers, and esteeme her selfe advanced to adorne our Townes, and take view of our Pomps and Spectacles.[28]

Every part of the New World, from the Straits of Magellan to Labrador, had its eager advocates, who alleged that a favorite region offered the safest base for a conquering navy.

> . . . this Countrey lyeth so neere the course which the Spanish ships, that come from *Mexico*, *Hauona*, and other places of the *West-Indies*, hold in their returne from thence, that they often saile within 190. leagues from the South part thereof,

wrote Whitbourne, arguing that an English plantation on Newfoundland would protect the route from the British Isles to New England, Virginia, and the Bermudas.[29] Others advocated the seizure of naval bases in the West Indies,[30] and some held Jamestown to be the proper center, provided only it was sufficiently well fortified.[31] All agreed, however, on the

armes . . . as if God had prescribed limits unto the Spanish nation. . . ." God also forbade the French to establish a "possession permenent" in North America (p. 37).

[25] "The Barbarians themselves by light of nature saw this, and gave Ours kind entertainment in mutuall cohabitation and commerce: . . . That natural right of cohabitation and commerce we had with others, this of just invasion and conquest, and many others praevious to this, we have above others . . . , *Purchas His Pilgrimes* XIX: 224.

[26] *Ibid.*, 258–259.

[27] *Nova Britannia*, Force, *Tracts* I: no. 6: 17.

[28] *Virginias Verger* in Purchas, *op. cit.*, XIX: 247. *Cf.* p. 249: "Yea, without a Navie, Salomon had not beene so meet a Type of Christ, so glorious in Domesticall, Politicall or Ecclesiasticall magnificance."

[29] Whitbourne, Richard, *A Discovrse and Discovery of Nevv-Fovnd-Land, With many reasons to proove how worthy and beneficiall a Plantation may there be made, after a far better manner than now it is*, 17–19, London, 1622.

[30] Writing from Roanoke to Sir Philip Sidney in 1585, Ralph Lane said that "yf her majesty shall, at eny tyme, finde her selfe burthened wyth the King of Spayene, wee have, by our dwellyng uppon yhe Iland of St. Jhon and Hyspagnyola for yhe space of 5 weekes, soe dyscouuered yhe forces thereof, wyth yhe infynytt ryches of yhe same, as that I fynd yt an attempt most honerable, fesyble, and proffytable, and only fytte for your selfe to bee cheeffe commander in. Thys entry wolde soe gaulle yhe King of Spain, as yt wolde dyuerte hys forces, yhat hee troublethe these partes of Chrystendome wyth, into thos partes where hee canne not gretely annoye vs wyth them." *Archchaeologia Americana* **4**: 17, 1860.

[31] See the interesting proposals for incorporation of a company to defend and protect the West Indies, to establish trade and to fit out a fleet to attack the Spanish settlements discussed in connection with Virginia in April, 1625. On April 22 the Privy Council directed Secretary Conway and the Master of Ordnance to take into consideration what forts and places of strength are to be erected and maintained in Virginia. *Cal. State Papers Col., 1574–1660*, 73, 79. The problem of fortifying the Jamestown settle-

intimate relation of plantations and an imperial naval policy:

> [Supplies] shall be made within those her Majesty's own dominions, by her own subjects, and brought hither through the ocean, free from the restraint of any other prince: whereby the customs and charges bestowed by our merchants (to the enriching of foreign estates) shall be lessened, and turned to the benefit of her Highness and her deputies in those parts; which also shall deliver our merchants from many troubles and molestations which they now unwillingly endure in our East trades; and shall make us the less to doubt the malice of those States which now we may not offend, lest we should be intercepted of the same provisions, to the weakening of our navy, the most royal defence of this noble realm.

Thus runs a typical paragraph in the Brereton-Hayes *Briefe and True Relation* of 1602, the second edition of which also quoted the "inducements to the liking of the Voyage intended towards Virginia," by "M. Richard Hakluyt the elder," among which one may read:

> By this ordinary trade we may annoy the enemies to Ireland, and succor the Queen's Majesty's friends there and in time we may from Virginia yield them whatsoever commodity they now receive from the Spaniard: and so the Spaniards shall want the ordinary victual that heretofore they received yearly from thence, and so they shall not continue trade, nor fall so aptly in practice against this government as now by their trade thither they may.[32]

Inasmuch as fear of the terrors of the deep interfered with colonization,[33] one can explain the printing of the account of seafights against the Spanish cheek by jowl with arguments for emigration only by noting the powerful place which anti-Spanish sentiments had in the nation as a whole. Such battles, if successful, showed that God was aiding the English navy against Spain. Thus Purchas described a fight between two Spanish men-of-war and a single English merchant vessel as being providentially directed:

> [The English ship was but] one poore Merchant and Passenger, being but a hundred and sixtie tunnes, having eight Iron Peeces and one Falcon, over-loaden with Stuffe and Wares, encombred with Passengers, toyled with a storme, tyred with a long Voyage, affrighted with wants, and every way insufficient to answere any such enemie: but as it is in the Scripture, it is all one to thee, O God, whether there be few or many, and Gedeons three hundred shall slay many thousands of the Midianites: as for deliverances, the people of Israell shall passe through the Red Sea dry foot: Jonas shall bee cast safe on shoare out of the Whales belly: and Paul shall escape shipwracke, saving his life with all his Passengers in the Iland of Malta.
>
> For to conclude with the purpose in hand, there is one thing most remarkable as an inducement to this our deliverance, that Captaine Chester embraced Doctor Bohune beeing mortally wounded, and thus recomforted him, saying O Doctor Bohune what a disaster is this; the Noble Doctor no whit exanimated replyed: Fight it out brave man, the cause is good, and Lord receive my soule.[34]

The putting down of piracy[35] and the long search for a Northwest Passage, which seems so

ment against maritime invasion was frequently before the Privy Council. See, e. g., p. 48 (1623), p. 66 (1624, the petition of Governor Sir Francis Wyatt and others to the king), pp. 99–100 (1629), Captain Harvey's proposals for a fort at Point Comfort), p. 109 (1630).

[32] *A Briefe and True Relation of the Discovery of the North Part of Virginia . . . by Captain Bartholomew Gosnold . . .* reprinted in *Mass. Hist. Soc. Coll.*, ser. 3, **8**: 83–123, 1843. The quotations may be found on pp. 100 and 105. This is a reprint of the second edition of the pamphlet. The first edition may be consulted in *Facsimile Reprints of Rare Books*, Hist. Ser. no. 2, New York, 1903. This is edited by Luther S. Livingston.

[33] Promises of safe passage constantly recur in promotion literature. Thus readers of Peckham's account are assured that "commonly one winde serveth to bring us thither," that the passage is short, even with an indifferent wind, that there is no danger from pirates, and that settlers will neither cross the equator nor run into ice. *Principal Navigations* VIII: 122–123. The Brereton-Hayes narrative declares that the voyage thither is "altogether free from all restraint by foreign princes" and favored by steady winds, *ed. cit.*, p. 96. Combatting the bad press which the shipwreck of Sir Thomas Gates received, the official *Trve Declaration* of 1610 argued both that Sir Thomas ran too far south and that God looked after expeditions, even when they were wrecked: ". . . he is too impiously fearefull, that will not trust in God so powerfull." Force, *Tracts* III, no. 1: 10–11.

[34] *A true Relation of a Sea Fight between two great and well appointed Spanish Ships, or Men of Warre; and an English Ship, called the Margaret and John, or the Blacke Hodge, going for Virginia*, in *Purchas His Pilgrimes* XIX: 142. Among the wounded on the Margaret and John was "William Bird Gentleman." The account of the seafight immediately precedes "Virginian affaires since the yeere 1620 till this present 1624."

[35] Piracy, often supposed to be instigated by the Spaniards, plays an important part both in the strategy of the period and in the promotion literature, writers either claiming that their plantation is safe from piracy or requiring government to suppress the pirates. See, among innumerable instances, *Cal. State Papers Col., 1574–1660*, characteristic entries in 1620, 25, and 1626, 82. Hakluyt argued generally that western planting would reduce the number of pirates (*Discourse of Western Planting, ed. cit.*, 36.). Gorges complained to Sálisbury of piracy (1611); see Baxter, *Sir Ferdinando Gorges* III: 171–172, hinting it

incomprehensible to the modern man, were alike associated with the desire to vanquish Spain.[36] Sir Humphrey Gilbert's whole discourse, for example, is a persuasion to hunt for the elusive strait, the reasons being, among others, that "the wealth of all the East parts" is "infinite," that the English "should be able to sell all maner of merchandize, brought from thence, farre better cheape then either the Portugall or Spaniard," that "great abundance of golde, silver, precious stones, cloth of gold, silkes, all maner of spices, grocery wares, and other kinds of merchandize of an inestimable price" will become an English monopoly to the detriment of Iberian trade, and that "we shall increase both our ships and mariners, without burthening of the state." [37] But passages about the North-west Passage as an instrument against Spain are innumerable: let John Davis speak for the Tudor and Stuart view of its importance:

> by the same passage in this ample vent, we should also, at first hand, receive all Indian commodities, both naturall and artificiall, in a far greter measure, by an easier rate, and in better condition then nowe they are by many exchaunges brought unto us. Then would all nations of Europe repayre unto England, not only for these forraine merchandizes by reason of their plenty, perfection, and easy rates, but also to passe away that which God in nature hath bestowed upon them and their countrie, whereby her majestie and her highnes successors for ever, should be monarks of the earth and commaunders of the Sea, through the aboundance of trade her customes would bee mightily augmented, her state highly inriched, and her force of shipping greatly advanced, as that thereby shee should be to all nations most dredful, and we, her subjects, through imploiment, should imbrace aboundance and be clothed with plenty.[38]

In sum, hatred of Spain merged easily into that romance of geography which dazzled the imagination of Marlowe and gave Hakluyt one of his most splendid passages:

> . . . it can not be denied, but as in all former ages, [Englishmen] have bene men full of activity, stirrers abroad, and searchers of the remote parts of the world, so in this most famous and peerlesse governement of her most excellent Majesty, her subjects through the speciall assistance, and blessing of God, in searching the most opposite corners and quarters of the world, and to speake plainly, in compassing the vaste globe of the earth more then once, have excelled all the nations and people of the earth. For, which of the kings of this land before her Majesty, had theyr banners ever seene in the Caspian sea? which of them hath ever dealt with the Emperor of Persia, as her Majesty hath done, and obteined for her merchants large & loving privileges? who ever saw before this regiment, an English Ligier in the stately porch of the Grand Signor at Constantinople? who ever found English Consuls & Agents at Tripolis in Syria, at Aleppo, at Babylon, at Balsara, and which is more, who ever heard of Englishmen at Goa before now? what English shippes did heeretofore ever anker in the mighty river of Plate? passe and repasse the unpassable (in former opinion) straight of Magellan, range along the coast of Chili, Peru, and all the backside of Nova Hispania, further then any Christian ever passed, travers the mighty bredth of the South sea, land upon the Luzones in despight of the enemy, enter into alliance, amity, and traffike with the princes of the Moluccaes, & the Isle of Java, double the famous Cape of Bona Speranza, arive at the Isle of Santa Helena, & last of al returne home most richly laden with the commodities of China, as the subjects of this now flourishing monarchy have done?[39]

might be due to unemployment. Smith, in a passage omitted from *New Englands Trials*, hinted priacy was due to the "desyre of gaine in Marchants" (*Works* I: cxxii). But the passages are innumerable.

[36] Search for the Northwest Passage is, of course, one of the oldest motives for English exploration. See, for example, Thorne's letter in Hakluyt's *Divers Voyages* or in *Principal Navigations*. What is of more significance is the lingering of the motive long after one might suppose that the growth of geographical knowledge had led to a belief in its impracticality. Thus in July, 1612, a North-West Passage Company was actually incorporated (*Cal. State Papers, East Indies, 1513–1616*, 238). In 1649 the author of *A Perfect Description of Virginia* said that the settlers were determined to explore westward "to find a way to a West or South Sea by land or river, and to discover a way to *China* and *East Indies* or unto some other Sea that shall carry them thither . . . and . . . all the question is only how broad the Land may be to that place from the head of *James* River above the Falls, but all men conclude if it be not narrow, yet that there is and will be found the like rivers issuing into a South Sea or a West Sea on the other side of those hills" Force, *Tracts* II, no. 8: 8. As late as 1658, in his *Briefe Narration* Sir Ferdinando Gorges hinted that Maine might hold the secret since his agents had heard rumor of a "people being cloathed with long robes, their heads bald or shaven, so as it is conceived they might be *Catayons* or *Chinawaies*" (Baxter, *op. cit.* II: 80). And in 1669 Governor Berkeley of Virginia told the English authorities that 200 gentlemen had agreed to accompany him on a western expedition apparently in search of a South Sea passage. Bruce, *Economic History of Virginia* I: 39, New York, 1907.

[37] See chap. 10 of his *Discourse* in *Principal Navigations* VII: 185, 186, 187.

[38] *The Voyages and Works of John Davis*, ed. A. H. Markham, London, Hakluyt Society, 1880. The quotation is from *The Worldes Hydrographical Discription*, 227, London, 1595.

[39] From the *Epistle Dedicatorie* of the first edition, *Principal Navigations* X: xx.

To sail into distant seas, create a navy, promote trade, plant colonies, and defeat Spain became one and the same thing.

4. THE POPULATION PROBLEM AND THE COMMON MAN

That England was actually suffering from a glut of population at the end of the sixteenth century may be doubted,[1] but that scores of writers thought England was over-populated is undeniable. Alarm over social dislocation is one of the commonest notes in Tudor literature. If the impact of the enclosure movement upon mediaeval agrarian economy has been exaggerated, "to suppose" Tawney writes "that contemporaries were mistaken as to the general nature of the movement is to accuse them of an imbecility which is really incredible." Throughout the century a significant fraction of the population silently moved out of its customary place in the mediaeval manor and drifted into the towns (to the alarm of the gilds) where they became an Elizabethan proletariat, or wandered the highways as sturdy beggars, dispossessed and homeless. "The sixteenth century lived in terror of the tramp." The tramp was a new social phenomenon with whom Tudor political science was scarcely equipped to deal—an able-bodied worker who, finding no employment, had been thrust outside the framework of society.

> O! when degree is shak'd,
> Which is the ladder to all high designs,
> The enterprise is sick. How could communities,
> Degrees in schools, and brotherhoods in cities,
> Peaceful commérce from dividáble shores,
> The primogenitive and due of birth,
> Prerogative of age, crowns, sceptres, laurels,
> But by degree, stand in authentic place?
> Take but degree away, untune that string,
> And, hark! what discord follows;[2]

Contemporaries were acutely conscious of the social discord resulting from the upsets in the old national economy. "Radical social changes were in progress . . . they bore with especial hardness on the lower classes of the people, and left a deep impress on the literature of the time." [3]

Against this background of social change a considerable part of the promotion literature must be read, if its meaning is to be understood. What may be called the sociological appeal of colonization plays its important part, the appeal being in some degree to all classes but principally to the socially dispossessed and those under the threat of being uprooted. All social ranks were apparently invited to ponder the threat and significance of over-population, which, from the beginning, looms large in the literature and for which plantations in the New World were confidently held to be a sovereign remedy. Thus Gilbert, among the eight numbered reasons of "commodities" which "would ensue," once the Northwest Passage was discovered, declares:

> Also we might inhabite some part of those countryes, and settle there such needy people of our countrey, which now trouble the common wealth, and through want here at home are inforced to commit outragious offences, whereby they are dayly consumed with the gallowes.[4]

Our prisons, wrote Hakluyt in the *Divers Voyages*, are "pestered and filled with able men to serue their Countrie, which for small roberies are dayly hanged vp in great numbers"—"twentie at a clappe" at Rochester—and we English ought to send them to the colonies.[5] ". . . yf this voyadge were put in execution," he wrote elsewhere,

> these pety theves mighte be condempned for certen yeres in the westerne partes, especially in Newefounde lande, in sawinge and fellinge of tymber for mastes of shippes, and deale boordes,

and in the south, they could be employed in mining, pearl-fishing, the growing of sugar cane, silkworms, cotton, various grains, grapes, and

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[1] For the background of this and the next section consult Georg Wiebe, *Zur Geschichte der Preisrevolution des XVI. und XVII. Jahrhunderts*, Leipzig, 1895; Earl J. Hamilton, American Treasure and the Rise of Capitalism (1500–1700), *Economica* **9**: 338–357, 1929; same, *American Treasure and the Price Revolution in Spain, 1501-1650, Harvard Economic Studies* **43**, Cambridge, 1934; John U. Nef, Prices and Industrial Capitalism in France and England, 1540–1640, *Economic History Review* **7**: 155–185, 1937 (corrects Hamilton in important particulars); Edward P. Cheyney, *Social Changes in England in the Sixteenth Century as Reflected in Contemporary Literature, Pub. Univ. Pennsylvania: Ser. in Philol. Lit. and Archaeol.* IV (2), 1895 (although sub-titled "Part I. Rural Changes," no second part seems to have been published); R. H. Tawney, *The Agrarian Problem in the Sixteenth Century*, London, 1912, especially parts ii and iii.

[2] *Troilus and Cressida*, Act I, scene iii, ll. 101–110.

[3] Tawney, *op. cit.*, 224; 268–269; 275–277; Cheyney, *op. cit.*, 7. Wrote Robert Cushman in his "Reasons and Considerations touching the Lawfulness of Removing out of England into the parts of America," ". . . there is such pressing and oppressing in town and country about farms, trades, traffic, so as a man can hardly anywhere set up a trade but he shall pull down two of his neighbours." Quoted in Tawney, p. 270.

[4] In *Principal Navigations* VII: 186. See also a similar passage in Peckham's report, in *do.* VIII: 112.

[5] *Divers Voyages, ed. cit.*, 8.

other "commodities." [6] Our idle soldiers, he wrote again, go

> up and downe in swarms for lack of honest intertainment, I see no fitter place to employ some part of the better sort of them trained up thus long in service, then in the inward partes of the firme of Virginia against such stubborne Savages as shal refuse obedience to her Majestie.[7]

Ministers of the gospel were equally concerned that colonization should prove a cure for over-population. The English, said Robert Gray in 1609, are as "the thousand of *Manasses*, and as the ten thousands of *Ephraim;*" they are entitled to exclaim, with the children of Israel, "we are a great people, and the lande is too narrow for ys," and, somewhat oddly, the good clergyman compared James I to Joshua.

> . . . although the honour of the king be in the multitude of people . . . yet when this multitude of people increaseth to ouer great a number, the commonwealth stands subiect to many perillous inconueniences. . . .[8]

"Look seriously into the land," preached William Symonds, "and see whether there be not just cause, if not a necessity, to seek abroad. The people, blessed be God, do swarm in the land, as young bees in a hive," and like a swarm of bees they must seek out a new home.[9] Colonization, thought John Donne,

> shall redeeme many a wretch from the Lawes of death, from the hands of the Executioner, vpon whom, perchance a small fault, or perchance a first fault, or perchance a fault heartily and sincerely repented, perchance no fault, but malice, had otherwise cast a present and ignominious death. It shall sweepe your streets, and wash your doores, from idle persons, and the children of idle persons, and imploy them: and truely, if the whole Countrey were but such a *Bridewell*, to force idle persons to work, it had a good vse . . . alreadie the imployment breedes Marriners; alreadie the place giues Essayes, nay, Fraights of Marchantable Commodities. . . .[10]

And Patrick Copland that same year praised the officers of the city of London,

> who seeing this Cittie to be mightly increased, and fearing lest the ouerflowing multitude of inhabitants should, like too much bloud in the body, infect the whole Cittie with *plague* and *pouertie*,

urged "the transporting of their ouer flowing multitude into *Virginia*." [11] John Smith, Richard Whitbourne, William Vaughan, Sir Ferdinando Gorges, John White, Sir William Alexander, Christopher Levett, "Mourt's Relation" —all the authorities were similarly conscious of the pressure of population upon the kingdom.[12]

The plantations were to cure over-crowding in Great Britain in a variety of ways. By one argument, implicit in the foregoing quotations and explicit elsewhere,[13] criminals were supposed to be reformed by contact with the New World and its opportunities for advancement. Many,

[6] *Discourse of Western Planting, ed. cit.*, 37. Because of the "multitudes of loyterers and idle vagabondes," many are "mutinous and seeke alteration in the state." Among these, the sick and disabled can be kept busy "makinge of a thousande triflinge thinges" to sell to the savages, the proof being that 14,000 persons in Antwerp have been employed in manufacturing articles sold to the English. The gain to the state will be immense: "when people knowe howe to live, and howe to mayneteyne and feede their wyves and children, they will not abstaine from mariage as nowe they doe" (pp. 36–43).

[7] From the dedicatory letter of the translation of *Laudonniere* in *Principal Navigations* VIII: 445.

[8] *A Good Speed to Virginia*, [6], London, 1609.

[9] Quoted from Symonds' sermon at Whitechapel, April 25, 1609, in Edward D. Neill, *The English Colonization of America during the Seventeenth Century*, 29–31, London, 1871.

[10] *A Sermon vpon The Eight Ver[s]e of the First Chapter of the Acts of The Apostles. Preached To the Honourable Company of the Virginian Plantation, 13. Nouemb. 1622*, 21–23, London, 1624; also in *X Sermons Preached by . . . John Donne*, ed. Geoffrey Keynes, 52, London, 1923.

[11] *Virginia's God be Thanked, or A Sermon Of Thanksgiving For The Happie successe of the affayres in Virginia this last yeare . . .* 31, London, 1622.

[12] Smith, *Description of New England*, 1616, *Works* I: 195–196; Richard Whitbourne, *A Discovrse and Discovery of New-Fovnd-Land . . .* London, 1620, introductory matter; William Vaughan, *The Golden Fleece . . .*, 3, London, 1626 (over-population in Scotland as well as in England); Sir William Alexander, *The Mapp and Description of New-England* in Laing, *op. cit.*, 38–41 (over-population in Scotland); Gorges, *A Briefe Narration of the Originall Undertakings of the Advancement of Plantations into the parts of America* in Baxter, *op. cit.* II: 6; John White, *The Planters Plea*, in Force, *Tracts* II, no. 3, chap. ii and iii; Christopher Levett, *A Voyage into New England* in James Phinney Baxter, *Christopher Levett, of York, The Pioneer Colonist in Casco Bay*, 128–129 Portland, The Gorges Society, 1893, (also in *Mass. Hist. Soc. Coll.* ser. 3, 184–185); *Mourt's Relation*, reprinted in Arber, *The Story of the Pilgrim Fathers*, 395–505, London and Boston, 1897 (this includes Cushman's "Reasons and Considerations touching the Lawfulness of removing out of England into the Parts of America," 495–505).

[13] Writing from Jamestown to Salisbury August 17, 1611, Sir Thomas Dale asks for men and says that "on account of the difficulty of procuring men in so short a time, all offenders out of the common gaols condemned to die should be sent for three years to the colony; so do the Spaniards people the Indies." *Cal. State Papers Col., 1574–1660*, 11. See the interesting comments by James I on Virginia as a reformatory, quoted by Neill in *Virginia Vetusta*, 101–103.

however, who asked for criminals, in order that a particular colony might be held, inconsistently condemned the kind of colonist they received.[14] Others argued that to transport idle young persons to the New World would decrease the number of potential criminals. For example, Higginson writes with pleasure that children of five can set out corn in New England, and exclaims:

> Oh what a good worke might you that are rich do for your poore brethren, to helpe them with your purses onely to convey them hither with their children and families, where they may live as well both for soule and body as any where in the world. . . . For when you are once parted with England you shall meete neither with taverns nor alehouses, nor butchers, nor grosers, nor apothecaries shops to helpe what things you need, in the midst of the great ocean, nor when you are come to land, here are yet neither markets nor fayres to buy what you want.[15]

The implication is that luxury corrupts. "It is thought convenient," says a fragmentary record of the Council for New England, "to admitt young youths from Parishes, that have not been taynted with any villanyes or misdemen.[rs], to bee sent to New England, and there to bee placed out and bound Apprentices to such as shall have occasion and meanes to imploy them."[16] The records of both the Virginia and the New England companies show a similar interest in shipping idle young paupers into the New World,[17] and the promotion literature reflects these activities. A letter from the Virginia Company to the City of London of 1609 outlines an attractive argument and a rosy future: the council is

> desirous to ease the city and suburbs of a swarme of unnecessary inmates, as a contynual cause of dearth and famine, and the very originall cause of all the Plagues that happen in this Kingdome,

urges that City raise a fund through the wards, and writes:

> And if the inmated called before you and enjoined to remove shall alleadge he hath not place to remove unto, but must lye in the streetes; and being offred to go this Journey, shall demaund what may be theire present mayntenance, what maye be theire future hopes? it may please you to let them Knowe that for the present they shall have meate, drinke and clothing, with an howse, orchard and garden, for the meanest family, and a possession of lands to them and their posterity, one hundred acres for every man's person that hath a trade, or a body able to endure day labour, as much for his wief, as much for his child, that are of yeres to do service to the Colony, with further particular reward according to theire particular meritts and industry.[18]

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[14] Thus Dale also writes: "Nor can I conceive how sutch people as we are inforced to bring over hither by peradventure, and gathering them up in sutch riotous, lasie and infected places can intertaine themselves with other thoughts or put on other behaviour then what accompanies sutch disordered persons, so prophane, so riotous, so full of Mutenie and treasonable Intendments, as I am well to witness in a parcell of 300 which I brought with me, of which well may I say not many give testimonie beside their names that they are Christians, besides of sutch diseased and crased bodies as the Sea hither and this Clime here but a little searching them, render them so unhable, fainte, and desperate of recoverie as of 300 not three score may be called forth or imploied upon any labour or service." Brown, *Genesis* I: 506–507. John Smith's complaints are well known. In his survey of *The Sagadahoc Colony* (Portland, The Gorges Society, 1892), Henry O. Thayer notes in the literature such passages as these: Alexander complains of colonists "pressed to the enterprise as endangered by the law or their own necessities"; Aubrey says that Popham "stockt or planted Virginia out of all the gaoles of England"; Wood says that Popham was "the first person who invented the plan of sending convicts to the plantation"; Fuller, in his *Worthies*, writes that "if the planters be such as leap thither from the gallows, can any hope for cream out of scum?" "It is rather bitterly than falsely spoken concerning one of our Western plantations consisting of most dissolute people." And in *The Planter's Plea* (1630) one reads: "It seems to be a common and grosse errour, that colonies ought to be Emunctories, or sinckes of states; to drayne away their filth . . . this fundamental errour hath been the occasions of the miscarraige of most of our colonies" (pp. 205–206 of Thayer).

[15] Thomas Wentworth Higginson, *Life of Francis Higginson*, 72, 75, New York, 1891.

[16] Records of the Council for New England, ed. Charles Deane, *Amer. Antiq. Soc. Proc.* **60**, Apr. 24, 1867, *Cal. State Papers Col., 1574-1660*, 30 (in part).

[17] In *Cal. State Papers Col., 1574–1660* one finds a catena of entries, e. g.: October, 1618, "The city is now shipping thither a hundred young boys and girls who lay starving in the streets," the charge not to be over five hundred pounds (p. 19). 1620, Sir Edwin Sandys writes to Secretary Sir Robert Naunton from London: "The City of London have appointed one hundred children, from their superfluous multitude, to be transported to Virginia, there to be bound apprentices, upon very beneficial conditions. Some of the ill-disposed children, who under severe masters in Virginia may be brought to goodness, and of whom the City is especially desirous to be disburdened, declare their unwillingness to go. The City wanting authority to deliver, and the Virginia Company to transport these children against their will, desire higher authority to get over the difficulty" (p. 23); July 5, 1622, the Council for New England discussed proposals to be made to the city of London for sending poor children fourteen years and upwards to New England (p. 33); etc., etc.

[18] Brown, *Genesis* I: 252–253.

In 1615 Ralph Hamor painted the Jamestown project in colors designed to attract the ordinary man:

> . . . now I dare and will boldly affirme to the greatest aduersary of the Plantation, that shall auer the contrary, that there is that plenty of foode, which euery man by his owne industry may easily, & both procure that the poorest ther, & most in want, hath not bin so much pinched with hunger [*sic*] this 4 yeers that if he would take any pains, he knew not wher to fetch a good meales meate: and true it is, that euery day by the prouidence, and blessing of God, and their owne industry, they haue more plenty then other, the reason hereof is at hand, for formerly, when our people were fedde out of the common store and laboured iointly in the manuring of the ground, and planting corne, glad was that man that could slippe from his labour, nay the most honest of them in a generall businesse, would not take so much faithfull and true paines in a weekc [*sic*], as now he will doe in a day, neither cared they for the increase, presuming that howsoeuer their haruest prospered, the generall store must maintain them, by which meanes we reaped not so much corne from the labours of 30 men, as three men haue done for themselues. . . .

Now that the colony has abandoned communism, Hamor asks for honest and industrious immigrants of the common sort,

> painefull people, such as either through crosses in this world, or ract rents, or else great charge of children and family liue heer [England], and that not without much care and sweat, into extreame pouerty: for those this Countrey hath present remedy.[19]

"The meaner sort," wrote Sir Robert Gordon of the successful Ulster experiment, "such as artisanes, labourers of the ground, the greater part whereof, were knowne to haue scarce a competent meanes to defray the charges of their passage thither, now promoted to bee Gentlemen, and of great meanes," and he hints that the same success will attend upon those who plant in Cape Breton.[20] John White pictured a colony as a replica of the mother-land, but an improved replica: "a State that intends to draw out a Colony for the inhabiting of another Country, must looke at the mother and the daughter with an equall and indifferent eye . . . and consequently must allow to her such a proportion of able men as may bee sufficient to make the frame of that new formed body," a frame which, if it included ministers, physicians, soldiers, and the like, also included "Mariners and Mechanicks of all sorts." To those who feared too great a drain upon the common people of England he retorted: "We are knowne too well to the world to love the smoake of our owne chimneyes so well, that hopes of great advantages are not likely to draw many of us from home." [21] "All kinds of Trades-men may live well there, and do gaine much by their labours and arts," wrote the author of *A Perfect Description of Virginia* (1649), "as Turners, Potters, Coopers; to make all kind of earthen and wooden Vessels, Sawyers, Carpenters, Tile-makers, Boat-wrights, Taylors, Shoemakers, Tanners, Fishermen and the like." Youths of sixteen and upward were wanted for apprentices and servants, "then to have Land given them, and Cattel to set them up," and the writer opined that there was room for "thousands of these kinds of young boyes and maydens." [22]

But the transitional qualities of the Tudor period are nowhere more patent than in the contradictory attitude shown in the promotion literature towards the common man. On the one hand, he was promised easy riches,[23] the possession of land in his own right,[24] and the

[19] *A Trve Discovrse of the Present Estate of Virginia* . . . 16–17, 19, London, 1615, (priv. printed, Albany, N. Y., 1860). He promises each family a handsome house of four or more rooms, twelve acres of ground, provisions for twelve months, tools, poultry, livestock.

[20] *Encouragements, For such as shall have intention to bee Vnder-takers in the new plantation of Cape Briton* . . . Edinburgh, 1625, [Sig. C3], in Laing, *op. cit.*

[21] *The Planters Plea*, Force, *Tracts* II, no. 3: 32.

[22] *A Perfect Description of Virginia* . . . ., London, 1649, in Force, *Tracts* II, no. 8: 7–8.

[23] "For labourers, if those that sowe hemp, rape, turnups, parsnips, carrats, cabidge, and such like; giue 20, 30, 40, 50 shillings yearely for an acre of ground, and meat drinke and wages to vse it, and yet grow rich; when better, or at least as good ground, may be had, and cost nothing but labour [in the New World]; it seems strange to me, any such should there grow poore." Smith, *Description of New England*, London, 1616, in *Works* I: 214. The passage could be endlessly duplicated in the literature.

[24] ". . . the dealing of Sir Walter Ralegh so liberall in large giving and granting lande there, as is already knowen, with many helpes and furtherances else: (The least that he hath granted hath bene five hundreth acres to a man onely for the adventure of his person) I hope there remaines no cause whereby the action should be misliked." Hariot's *Virginia*, in *Principal Navigations* VIII: 385. "A poore Seruant here that is to possesse but 50 Acres of Land, may afford to giue more wood for Timber and Fire as good as the world yeelds, then many Noble Men in *England* can afford to doe. Here is good liuing for those that loue good Fires." Francis Higginson, *New Englande Plantation. Or, A Short and Trve Description of the Commodities and Discommodities of that Countrey*, London, 1630, in Force, *Tracts* I, no. 12: 11.

opportunity to stabilize his family.[25] On the other hand, the promotion literature is filled with complaints about the unruliness, the lack of discipline, the insubordination and the want of practical sense exhibited by the Tudor commoner during the period of exploration and first settlement. According to Raleigh, the chief cause of the failure of his second voyage to Guiana was that, some forty gentlemen excepted, his forces were composed of "the very scum of the world, drunkards, blasphemers, and such others as their fathers, brothers, and friends thought it an exceeding good gain to be discharged of." [26] Sir Ferdinando Gorges complained of the "idle proceedinges" of his colony which "have mutch prejudcialld the publique good, devidinge themselves into factions, each disgracing the other, even to the Savages, the on[e] emulatinge the others reputation amongst those brutish people." [27] Conspiracies among the commoners brought both the original Jamestown plantation and the shipwrecked "supply" of Sir Thomas Gates to the verge of ruin.[28] Some deserted and, returning to England, spread scandal; [29] and on those who remained Captain John Smith poured his scorn.[30] English fishermen on the Maine coast were "worse than the very Savages, impudently and openly lying with their Women, teaching their Men to drinke drunke, to sweare and blaspheme the name of *GOD*, and in their drunken humour to fall together by the eares. . . ." [31] And Edward Winslow makes a similar complaint of Weston's colony, listing among the three causes of the "overthrow and bane" of plantations the carelessness of those that send over men too often "endued with bestial, yea, diabolical affections." [32] Only gradually in a given colony did an "honest and vertuous" minority emerge out of the confusion, as John Hammond noted of Virginia, which had become, he thought, "a modell on which industry may as much improve itself in, as in any habitable part of the World." [33]

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[25] "Be it so, art thou a Labourer, that desirest to take paines for the maintenance of thy selfe, the imployments in Plantations gives the not onely extraordinary wages, but opportunity to build some House or Cottage, and a proportion of Land agreeable to thy fortunes to set thy selfe, when either lamenesse or other infirmities seize on thee, hast thou a Wife and a Family, by plantation thou buildest, inclosest, and dost labour to live, and enjoy the fruits thereof with plenty, multiplying thy little meanes for thy Childrens good when thou art no more." Gorges, *Briefe Narration*, London, 1658, in Baxter, *op. cit.* II: 79.

[26] *The Discovery of Guiana* in *Works*, VIII: 480, 1829.

[27] Letter of February 7, 1607, in Baxter, *op. cit.* III: 161.

[28] At Jamestown, James Read, the blacksmith, was condemned to be hanged for mutiny, but "became penitent, and declared a dangerous conspiracy: for which Captaine *Kendall*, as principal, was by a Iury condemned, and shot to death." Smith, *Trve Relation*, *Works* I: 12–13. Shipwrecked on Bermuda under conditions which required complete cooperation, Sir Thomas Gates' expedition soon discovered "some dangerous and secret discontents nourished amongst us." These "began first in the Seamen, who in time had fastened unto them (by false baits) many of our land-men likewise, and some of whom (for opinion of their Religion) was carried an extraordinary and good respect." The mutinous included a smith, a carpenter, and others. Two other mutinies followed upon the first and included a design to assassinate the governor. See Strachey's *True Reportory* in *Purchas His Pilgrimes* XIX, especially pp. 28–36. The author of *Virginias Verger* is especially severe on popular factionalism at Jamestown: failure there was due, he says, to "Division, that taile-headed Amphisbæna and many-headed monster, deformed issue of that difformed old Serpent" which "in some of the Colony there & Company here, hath from time to time thrust in her forged venemous tongue," and he says that for "A long time Virginia was thought to be much encombered with Englands excrements, some vicious persons, as corrupt levin sowring, or as plague sores infecting others, and that Colony was made a Port Exquiline for such as by ordure or vomit were by good order and physicke worthy to be evacuated from This body" *ibid.*, 236.

[29] Thus *A Publication by the Counsell of Virginea, touching the Plantation there* (1610) excoriates certain "unruly youths sent thither" who "were suffered by stealth to get aboard the ships returning thence, and are come for *England* againe, giving out in all places . . . most vile and scandalous reports, both of the Country itselfe, and of the Cariage of the businesse there." See Brown, *Genesis* I: 354.

[30] "All this time our old taverne made as much of all them that had either mony or ware as could bee desired; and by this time they were become so perfect on all sides (I meane Souldiers, Sailers, and Salvages,) as there was ten times more care to maintaine their damnable and private trade, then to provide for the Colony things that were necessary. . . ." Such are "the Saint-seeming worthies of *Virginia*." *The Proceedings of the English Colonie in Virginia*, in Smith, *Works* I: 127–128. See also *A Map of Virginia*, 1612, in *do.*, 83–84.

[31] ". . . besides, they couzen and abuse the Savages in trading and trafficking, selling them Salt covered with Butter in stead of so much Butter, and the like," and also trading in firearms. Gorges, *Briefe Narration*, in Baxter, *op. cit.* II: 42.

[32] *Good News from New England: or a true Relation of things very remarkable at the Plantation of Plymouth in New England* . . . , London, 1624, in Arber, *Story of the Pilgrim Fathers*, 511, 515.

[33] *Leah and Rachel* 1656, in C. C. Hall, *Narratives of Early Maryland*, 287. Hammond observes that Virginia is neither Lubberland nor Utopia, but that "the inhabitants now finding the benefit of their industries, began to look with delight on their increasing stocks (as nothing more pleasurable then profit), to take pride in their plentifully furnished Tables, to grow not onely civil, but great

Wherefore, though John Smith might write in 1616 of New England that

here are no hard Landlords to racke vs with high rents, or extorted fines to consume vs; no tedious pleas in law to consume vs with their many years disputations for Iustice; no multitudes to occasion such impediments to good orders, as in popular States,[34]

the writer of promotion literature was inevitably caught between the contradictory claims of authority and liberty. On the one hand, except by creating a small, quasi-feudal military garrison and trading post supported by communal enterprise, the Tudor mind could find no way to assure to the individual colonist adequate protection from enemies and initial sustenance; on the other hand, since each settler looked forward to making his private fortune on *laissez-faire* principles, he chafed against the restrictions of communal enterprise, which were eventually abandoned. The contradiction lay deep in Tudor life;[35] it appears in the colonial literature from the beginning; and it was never logically resolved. Thus, in the very pamphlet in which he pleads for the creation of a company to colonize Newfoundland, Sir George Peckham sets forward the inducement that each investor may nevertheless retain for himself, his children, his apprentices, and his servants, complete freedom in trade and traffic.[36] Creating a colony might be either a corporate or a state enterprise *ab initio*, but it was impossible to reconcile communal demands with such promises to the common man as appeared in R. Rich's *Newes from Virginia:*

To such as to Virginia
Do purpose to repaire;
And when that they shall hither come,
Each man shall have his share,
Day wages for the laborer,
And for his more content,
A house and garden plot shall have,
Besides 'tis further ment

That every man shall have a part,
And not thereof denied
Of generall profit, as if that he
Twelve pounds, ten shillings paid.[37]

In vain did the Council for Virginia (in London) direct that

You must take care that your mariners that go for wages do not mar your trade, for those that mind not to inhabit, for a little gain will debase the estimation of exchange, and hinder the trade for ever after; and therefore you shall not admit or suffer any person whatsoever, other than such as shall be appointed by the President and Counsel there, to buy any merchandizes, or other things whatsoever.

It were necessary that all your carpenters, and all other such-like unknown about building, do first build your store-house, and those other rooms of public and necessary use, before any house be set up for any private person; and though the unknown may belong to any private persons, yet let them all work together—first for the Company, then for private men.[38]

In vain did Smith fume because, the leaders being sick, "the rest being in such dispaire, as they would rather starue and rot with idlenes, then be perswaded to do any thing for their owne reliefe without constraint."[39] In vain did Gates, De la Warr, and Strachey denounce the anarchic individualism at Jamestown. Communal enterprise was not attractive to the common man:

observers of the Sabbath, to stand upon their reputations, and to be ashamed of that notorious manner of life they had formerly lived and wallowed in" (p. 286).

[34] *A Description of New England*, in *Works* I: 195–196.

[35] Two documents cited by Tawney and Power illustrate this truth. "A Discourse of Corporations," which dates from the eighth decade of the sixteenth century, is far from enthusiastic about "monopoly": "Here have I occasion to touche the maintenaunce of the Navie, so muche avaunted of since the strangers withdrewe them from our Costes. It may not be denied but that the same is carefullie to be mainteyned as a thinge wherin consisteth the strengthe and defence of our Cuntrey. *But the same shalbe better mainteined by multitude of marchantes then by a fewe, wherevnto the Corporacions threaten the Realme* . . . [italics mine]. *Tudor Economic Documents* III: 273. But in John Wheeler's *A Treatise of Commerce, wherein are shewed the commodities arising by a wel ordered and ruled Trade* (Midddleburgh, 1601), one reads that "since the troubles began with Spaine not one shippe sett out by the Companie of M.M.Adventurers hath been taken by the enemie; whereas the single Merchaunt, goeing where and when he listeth, and not able to sett a good shippe on worke, casteth how to come of good cheape, and either shippeth in straungers, or provideth him self of small vessels and pinkes to serue his turne . . . fitt to flie or runne awaye . . . and yet he is many times snapped vp, and made a pray to the Dunkerkers, and other sea rovers . . ." (*do.*, p. 296).

[36] *Principal Navigations* VIII: 116–117.

[37] Said to be the earliest narrative of the wreck of the *Sea Venture*, this ballad may be found in Edward D. Neill, *Early Settlement of Virginia and Virginiola*, 29–35, Minneapolis, 1878.

[38] Quoted in *ibid.*, 6–7.

[39] *True Relation*, in *Works* I: 9. See also Strachey's *True Reportory, passim*, in *Purchas His Pilgrimes* XIX: 5–72.

The reason heereof is at hand, for formerly, when our people were fed out of the common store, and laboured joyntly in the manuring of the ground, and planting Corne, glad was that man that could slip from his labour; nay, the most honest of them in a generall businesse, would not take so much faithfull and true paines, in a weeke, as now hee will doe in a day, neither cared they for the increase, presuming that howsoever their harvest prospered, the generall store must maintayne them. . . . To prevent which mischiefe hereafter Sir Thomas Dale hath taken a new course, throughout the whole Colonie, by which meanes, the generall store (apparell onely excepted) shall not bee charged with any thing: and this it is, hee hath allotted to every man in the Colonie, three English Acres of cleere Corne ground, which every man is to mature and tend . . . and they are not called unto any service or labour belonging to the Colonie, more then one moneth in the yeere, which shall neither be in Seed time, or in Harvest, for which, doing no other dutie to the Colonie, they are yeerely to pay into the store two barrels and a half of Corne: there to bee reserved to keepe new men. . . .[40]

Thus did Virginia swing away from Utopia, a change which the New England settlements also underwent. It is significant perhaps that with the abandoning of the communal idea appeals to the common man in the promotion literature become increasingly specific. A passage from Hammond's *Leah and Rachel* (1656) will serve to illustrate this point:

. . . never any servants of late time have gone thither, but in their Letters to their Friends commend and approve of the place . . . seldom (if ever) any that hath continued in Virginia any time, will or do desire to live in England, but post back with what expedition they can; although many are landed men in England, and have good estates there. . . . The labour servants are put to, is not so hard nor of such continuance as Husbandmen, nor Handecraftmen are kept at in England.

The women, wrote Hammond, unless they are "wenches that are nasty, beastly and not fit to be so imployed," do no farm work; indentured servants may buy themselves free in a land populous with "sober, modest persons."

. . . of such a happy inclination is the Country, that many who in England have been lewd and idle, there in emulation or imitation . . . not onely grow ashamed of their former courses, but abhor to hear of them, and in small time wipe off those stains they have formerly been tainted with. . . .

In sum, the population problem was solved, it seemed, on the basis of individual initiative.

Several ways of advancement there are and imployments both for the learned and laborer, recreation for the gentry, traffique for the adventurer, congregations for the ministrie (and oh that God would stir up the hearts of more to go over, such as would teach good doctrine, and not paddle in faction, or state matters; they could not want maintenance, they would find an assisting, an imbracing, a conforming people).[41]

Perhaps the case of the Gorges colony is the classic instance of the theoretical desirability and the practical failure of the communal doctrine of plantation-making. The founders sought to establish the colony

by setling such liberties and orders in the westerne cities and townes, as might induce euery reasonable man in, and about them, affecting the publike good, or a regular proceeding in the businesse of trade, to embrace an vniformitie, and to ioyne in a communitie, or ioynte stock together: How reasonable or vnreasonable those orders were, is hereafter to be seene, and iudged by eury well affected person, or any truly louing the publike good of our Nation. . . .

But obstreperous individualism overthrew the scheme:

. . . euery particular man thought himselfe strait debarred of libertie to run his owne currant, in which he thought his freedome did onely consist; and by debarring him thereof, his priuate ends were ouerthrowne, which was to endeauour to preuent his neighbour of the market he aimed at, or the Harbour he resolued to goe vnto, or the present trade hee expected to haue by his priuate industrie, but as for the publique hee cared not, let that fare as it would.[42]

5. THE APPEAL OF TRADE

A plantation, however, was not merely a place for the display of *virtù*, a pawn in international diplomacy, or a safety valve for surplus commoners, it was also—perhaps primarily—a trading post. Beside the gentleman, the statesman, and the commoner stood the merchant,

> he whose travaile ought
> Commodiously, to doe his countrie good,
> And by his toyle, the same for to enriche,

[40] *Notes of Virginian affaires in the government of Sir Thomas Dale and of Sir Thomas Gates till Anno 1615. Taken out of Master Ralph Hamor (Secretary to the Colonie) his Booke* in *Purchas His Pilgrimes* XIX: 95–96.

[41] *Leah and Rachel*, in Hall, *Narratives of Early Maryland*, 290–299, *passim*.

[42] Gorges, *A briefe Relation*, 1622, in Baxter, *op. cit.* I: 223–224.

as George Gascoigne wrote in *The Steele Glas*.[1] A passage in John Wheeler's *A Treatise of Commerce* (1601), though it describes the entry of Philip into Antwerp in 1549, gives us some sense of the power and importance of the Tudor merchant:

> Maister Iohn Sturgeon, at that tyme Gouuernour of the Companie, was at the receyuing in of the said Prince accompanied with thirtie Merchantes of the Companie on horse-back all in a liuerie of Purple veluit in grain coates, and paneld hose embrodered full of siluer waues like the waues of the sea; their Dublettes and drawinge out of their hose purple sattin, their Hattes of purple veluit with golde bandes, faire brouches, and white feathers; and each of them a chain of golde about his neck of great valew; buskins of purple velvitt; their Rapiers, Daggers, Spurres, Stirropps and Bridles all gilt; the furniture of their horses was of purple veluit, Sadles and Trappinges, etc., embrodered with golde, and greene silke and white, and green feathers on their horse heades: they were attended with three skore Lackies, apparailed in white veluitt ierkins cutt, embrodered with siluer twist, green sattin dublettes, with hose and buskins of the same, purple veluitt Cappes, and green Feathers: behinde them roade the abouesaid Gouernour vpon a white English gelding, in a longe purple veluitt gowne, lyned with purple sattin, a black velvitt coat, and cappe with a fair brouche therein, and a chain of golde about his neck: his Dublett and Hose, with the trappinges of his Horse, were as the other of his Companie wore; he was attended on by six Lackies on foot, and three Pages on horseback apparailed as aforesaid. In which their doeing they shewed themselues for the honour of their Prince and Cuntrye nothing inferiour to the Merchantes of other nations. . . .[2]

If one is to avoid the common error of thinking about the Tudor merchant as if he were a Victorian shopkeeper, one must keep steadily in mind the implications of the last sentence: "in which their doeing they shewed themselues for the honour of their Prince and Cuntrye nothing inferiour to the Merchantes of other nations." The Tudor investor wanted good returns on his money, but he was also susceptible to the appeal of patriotism and glory.

Perhaps the commonest element in the promotion literature is the allure of economic plenitude. The sober prose of the discoverer became as gorgeous as the verse of Spenser in enumerating the endless commodities of the New World, and the catalogues of the vegetable, animal, and mineral kingdoms are as encyclopaedic as the *Polyolbion*. Out of a hundred instances two or three must suffice. Thus concerning Newfoundland Anthony Parkhurst could write:

> As touching the kindes of Fish beside Cod, there are Herrings, Salmons, Thornebacke, Plase, or rather wee should call them Flounders, Dog fish, and another most excellent of taste called of us a Cat, Oisters, and Muskles, in which I have found pearles above 40. in one Muskle, and generally all have some, great or small. . . . There are also other kinds of Shel-fish, as limpets, cockles, wilkes, lobsters, and crabs: also a fish like a Smelt which commeth on shore, and another that hath the like propertie, called a Squid: these be the fishes, which (when I please to bee merie with my old companions) I say, doe come on shore when I commaund them in the name of the 5. ports, and conjure them by such like words: These also bee the fishes which I may sweepe with broomes on a heape, and never wet my foote, onely pronouncing two or three wordes whatsoever they be appoynted by any man, so they heare my voyce: the vertue of the words be small, but the nature of the fish great and strange. . . . Smelt you may take up with a shove-net as plentifully as you do Wheate in a shovell, sufficient in three or foure houres for a whole Citie.

The good Parkhurst tells with a twinkle in his eye about "trees that bare Oisters," but, letting "these merrie tales passe," he urges trading and settlement upon Hakluyt,[3] to whom he is writing. Of the "North Part of Virginia" the Brereton-Hayes narrative lists innumerable birds, animals, and fish; remarks upon fish, whale, seal oils, soap ashes and soap, tar and pitch, rosin and turpentine, masts, timber and boards of cedars, firs and pines, hemp, flax, cables and ropes, sail cloths, grapes, raisins, wines, corn, rape-seed and oils, hides, skins, furs, dyes and colors for painting, pearls, metals and other minerals as marketable products "after that we have planted our people skilful and industrious." In fact, the account prophesies a shift in the balance of world trade, since "northern Virginia" will produce commodities

> for the which all nations that have been accustomed to repair unto the Newfoundland for the commodity of fish and oils alone, will henceforward forsake the Newfoundland, and trade with us, when once we have planted people in those parts. . . . Then will the Spaniards and Portugals bring unto us in exchange . . . wines, sweet oils, fruits, spices, sugars,

[1] *Works*, ed. J. W. Cunliffe, II: 162, Cambridge, 1910.

[2] Tawney and Power, *Tudor Economic Documents* III: 302–303.

[3] *Principal Navigations* VIII: 13.

silks, gold and silver, or whatsoever that Europe yieldeth to supply our necessities and to increase our delights.[4]

Enumerating twenty-five "arguments of particular comodities and commodiousnesse," the author of *Virginias Verger*, said in his odd style that

the Lands and seas contend by fresh Rivers and Armes of the Sea so to diversifie the soyle as if in luxuriant wantonnesse they were always engendring manifold Twinnes of Commoditie and Commodiousnesse, Profit and Pleasure, Hunting and Fishing, Fruits and Merchandizing, Marinership and Husbandry, Opus and Usus, Meate and Drinke, Wares and Portage, Defending and Offending, Getting and Keeping, Mountaines and Valleyes, Plaines and Hillocks, Rivers Navigable and shallower Foords, Ilands and Land-iles (or Peninsulæ), Woods and Marishes, Vegetatives and living creatures marvellously diversified,

in sum a land productive of trees for timber, diversified crops, silk, wines, drugs, iron, naval stores, cattle—an indefinite list

not only usefull at all times, but necessary to these times, as to transport superfluous numbers from hence to Virginia, so to cure the diseases of the times caused by the wants of Monies (the life of trading, and sinewes of a great State) attended with wants of sale for the Merchant, and consequently of Clothiers and other subordinate professions . . . and . . . want of trading for Citizens. . . .[5]

The official *Trve Declaration of the estate of the Colonie in Virginia* (1610) simply underlines the mercantile appeal:

Vvat these things will yeelde, the Merchant best knoweth, who findeth by experience, that many hundreth of thousands of pounds are yearly spent in Christendome [on commodities that might come from Virginia]. The Merchant knoweth, that Caueare and Traine which come from Russia, can be brought hither but once in the yeare, in regard of the Ice: and that Sturgeon which is brought from the East countries, can come but twice a yeare; and that not before the end of Aprill, or the beginning of May; which many times in regard of the heate of those moneths, is tainted in the transportation: when from Virginia, they may be brought to vs in foure and twenty daies, and in all the colde seasons of the yeare. The Merchants know, that the commodity of sope and pot ashes are very scant in Prussia; that they are brought three hundred miles by land, and three hundred miles by riuers, before they come to the Sea; that they pay a custome there, and another in Denmarke, which enhanceth the prices exceedingly; But in Virginia they may haue them without carriage by land or custom (because fiue Nauigable Riuers doe lead vp fiue seueral waies into the bowels of the whole countrey.) As therefore the like Riuers, are the cause of the riches of Holland, so will these be to vs a wondrous cause of sauing of expences. The merchant knoweth, that through the troubles in Poland & Muscouy, (whose eternall warres are like the Antipathy of the Dragon & Elephants) al their traffique for Mastes, Deales, Pitch, Tarre, Flax, Hempe, and Cordage, are euery day more and more indangered, and the woods of those countries are almost exhausted. All which are to be had in Virginia with farre less charge, and farre more safety. Lastly, the Merchant knoweth, that for our commodities in the Straights, as sweet wines, orenges, lemmonds, anniseeds, &c. that we stand at the deuotion of politique Princes and States, who for their proper vtility, deuise all courses to grinde our merchants, all pretences to confiscate their goods, and to draw from vs al marrow of gaine by their inquisitiue inuentions: when in Virginia, a few yeares labour by plant and husbandry, will furnish all our defects, with honour and security. . . .[6]

Small wonder that the satirical authors of *Eastward Ho* (1605) put into the mouth of the rascally Seagull such language as this:

I tell thee, gold is more plentiful there than copper is with us; and for as much red copper as I can bring, I'll have it thrice the weight in gold. Why, man all their dripping-pans, and their chamber-pots are pure gold; and all the chains with which they chain up their streets are massy gold; all the prisoners they take, are fettered in gold; and for rubies and diamonds, they go forth on holidays and gather them by the seashore, to hang on their children's coats, and stick in their caps, as commonly as our children wear saffron guilt Brooches and groates with holes in them.[7]

The economic motivation varied little during the decades of the promotion literature. Because the mercantilist theory of political economy laid stress upon the possession of gold and silver as the incarnation of wealth rather than as a means to wealth, the phantom of mineral treasures hung ever on the horizon. Frobisher loaded his ships with "such stone or supposed gold minerall" as he could find in the frozen north;[8] Ralph Lane sought for a mine in

[4] *A Briefe and True Relation of the Discovery of the North Part of Virginia*, 1602, *Mass. Hist. Soc. Coll.* ser 3, **8**, 1843.

[5] In *Purchas His Pilgimes* XIX: 243–252.

[6] In Force, *Tracts* III, no. 1: 22–23.

[7] A. H. Bullen, *Works of Ben Johnson* III: 63.

[8] See Settle's account of Frobisher's second voyage in *Principal Navigations* VII: 221.

Roanoke, "for that the discovery of a good Mine, by the goodnesse of God, or a passage to the South-sea, or some way to it, and nothing els can bring this Countrey in request to be inhabited by our nation";[9] Raleigh turned *The Discovery of Guiana* into a golden poem;[10] the letters patent issued to all the explorers stipulated the search for precious metals as foremost among the aims of the crown;[11] the waste of energy at Jamestown caused by the futile search for gold is well known; and even as late as 1628 the Privy Council was considering petitions for the formation of a company to work gold and silver mines in the West Indies.[12] And when no gold turned up in Virginia, apologists were hard put to it to get over the difficulty, which they explained on moral grounds.[13]

The mercantile theory also implied the monopoly of trade by the mother country, the cutting off of trade between the plantations and foreign powers, and the substituting of colonial commerce for foreign commerce on the part of the mother country, as we have seen.[14] This trade meant traffic in fish,[15] marine stores,[16] furs and similar goods; it meant also, as has been hinted, the creation of a trading post[17] and the "civilizing" of the natives so that they would desire to buy English manufactures. The Indians, wrote Peckham,

> so soone as they shall begin but a little to taste of civility, will take marvelous delight in any garment, be it never so simple; as a shirt, a blew, yellow, red, or greene cotten cassocke, a cap, or such like, and will take incredible paines for such a trifle . . . vent for our English clothes will thereby ensue, and how great benefit to all such persons and artificers . . . I do leave to the judgment of such as are discrete . . . all such townes and villages, as both have beene, and now are utterly decayed and ruinated (the poore people thereof being not set on worke, by

[9] *An Account of the particularities of the imployments of the English men left in Virginia by Sir Richard Greenevill under the charge of Master Ralph Lane* . . . in *ibid.* VIII: 331.

[10] "In Guiana itself I never saw marcasite, but all the rocks, mountains, all stones in the plains, in woods, and by the rivers' sides, are in effect through shining, and appear marvellous rich; which being tried to be no marcasite, are the true signs of rich minerals, but are no other than *el madre del oro* (as the Spaniards term them) which is the mother of gold, or, as it is said by others, the scum of gold. . . ." Raleigh, *Works, ed. cit.*, VIII: 385. See also pp. 387, 397, 399, 403.

[11] See, e. g., section IX of the latters patent to Sir Thomas Gates and others in Brown, *Genesis* I: 52 ff.

[12] *Cal. State Papers Col., 1574-1660*, 95.

[13] Gold and silver occasion violence, argues the author of *Virginias Verger*, since they are "never produced to light but by violence, and convinced, upon records written in bloud, the occasioners of violence in the World; which have infected the surface of their native earth with deformity and sterility (these Mines being fit emblemes of mindes covetous, stored with want, and ever wanting their owne store) her bowels with darknesse, damps, deaths, causing trouble to the neighbour Regions, and mischiefe to the remotest!" *Purchas His Pilgrimes* XIX: 232.

[14] It must be remembered that English trade in the last half of the sixteenth century and in the opening decades of the seventeenth was apparently being choked off. Algerine piracy and Venetian hostility checked Mediterranean commerce; trade with France declined; the Netherlands were absorbed in their struggles against Spain; in the Baltic the Hanseatic cities were hostile, and so was Denmark; and Russia imposed a customs barrier See *The Trade's Increase, Harleian Miscellany* IV: 202 ff., 1745.

[15] Literature having to do with the northern coastline is especially concerned with fishing. Thus the Brereton-Hayes *Relation* already cited urges the desirability of increasing traffic with fishermen on the Newfoundland banks; Richard Whitbourne goes into elaborate calculations about fishing and investments in boats in *A Discourse Containing A Loving Invitation . . . for the Aduancement of his Maiesties most hopefull Plantation in the Newv-Found-Land*, 14–21, London, 1622; John Mason exclaims that the fishing was likely to "swallow vp and frowne my senses not being able to comprehend or expresse the riches therof," in *A Briefe Discovrse of the Newv-found-land*, 1620 (in Laing, *op. cit.*), etc.

[16] "1. All Kingdoms are maintained by rentes or traffique, but especially by the latter which in maritime places most florisheth by means of Navigation. 2. The Realme of England is an Islande impossible to be otherwise fortifyed than by strong shipps and able mariners, and is secluded from all comers, with those of the maine continent, therefore fit abundance of vessels be prepared to export and import merchandize. 3. The furniture of shipping consists in Masts, cordage, pich, tar, Rossen, yet of which England is by nature unprovided, and at this point enjoyeth them only by the favor of forraigne patents . . . 11. That Realme is most compleet and wealthie which either hath sufficient to serve itselfe or can find the meanes to exporte of the naturall comodity when it hath occasion necessarily to importe, consequently it must inforce that by a publique consent, a Collony transported into a good and plentiful climate able to furnish our wants, our meines, and wares that nowe run into the handes of our adversaries, or cowld frendse, shall pass unto our frendse and natural kinsmen. . . ." "Reasons or Motives for the raising of a publique stock to be employed for the peopling and discovering of . . . Countries" in Neill, *Virginia Vetusta*, 28–30. See also Brown, *Genesis* I: 37–41. Similar arguments are plentiful in the literature.

[17] The letters patent to Sir Thomas Gates and others direct them to fortify a post on a river, and if the river comes out of a lake, "the passage to the other sea will be the more easy, and is like enough that out of the same lake you shall find some spring which runs the contrary way toward the East India Sea" on the example of the Volga, Tanais, and Dwina rivers, great avenues of trade (Brown, *Genesis* I: 83).

reason of the transportation of raw wooll of late dayes more excessively then in times past) shal by this meanes be restored to their pristinate wealth and estate. . . .[18]

And the great virtue of the New World was that the voyage thither was "altogether free from all restraint by foreign princes." [19]

6. THE MORAL SANCTION

But was it lawful to intrude upon the harmless savages? To claim sovereignty over lands that conceivably belonged to the Emperor of China or at least the Emperor Powhatan? Casuistical writers went presently to work, some in the field of ethics, some in the field of religion, to find moral sanctions for the making of plantations.

For one thing, it was obviously God's Providence that had reserved North America for the English. "As is to be conjectured by infallible arguments of the world's end approaching," wrote Edward Hayes, the English are

now arrived unto the time by God prescribed of their vocation, if ever their calling unto the knowledge of God may be expected. Which is also very probable by the revolution and course of Gods word and religion, which from the beginning hath moved from the East, towards, & at last unto the West, where it is like to end, unlesse the same begin againe where it did in the East, which were to expect a like world againe.[1]

"In my private opinion," said Sir George Peckham, "I do verily thinke that God did create land, to the end that it should by culture and husbandry yeeld things necessary for mans life."[2] "Who will thinck yt an unlawfull act," inquired William Strachey,

to fortefie and strengthen our selves (as nature requires) with the best helpes, and by sitting downe with guardes and forces about us in the wast and vast inhabited grownde of their[s], amongst a world of which not one foote of a thousand doe they either use, or knowe how to turne to any benefitt; and therfore lyes so great a circuit vayne and idle before them? Nor is this any injurye unto them, from whome we will not forceably take of their provision and labours, nor make rape of what they clense and manure; but prepare and breake up newe grownde, and therby open unto them likewise a newe waye of thrift or husbandry. . . .[3]

"Their land," says Robert Cushman, "is spacious and void"; the Indians "do but run over the grass, as do also the foxes and wild beasts"; wherefore "As the ancient Patriarchs therefore removed from straiter places into more roomthy . . . so it is lawful now to take a land, which none useth; and make use of it." [4] The rule of nature, thought John Donne, permitted the English to occupy, since the natives had failed to use their land.[5] God, argued John Winthrop, gave the earth to man; "why then should we stand starving here for places of habitation?" [6] John White held to the same opinion:

If it were then the minde of God, that man should possesse all parts of the earth, it must be enforced that we neglect our duty, and crosse his will, if we doe it not, when wee have occasion and opportunitie. . . . It cannot be denyed but the life of man is every way made more comfortable, and afforded a more plentiful supply in a larger scope of ground, which moves men to bee so insatiable in their desires to joyne house to house, and land to land, till there be no more place . . . the husbanding of unmanured grounds, and shifting into empty Lands, enforceth men to frugalitie, and quickneth invention: and the setling of new States requireth justice and affection to the common good: and the taking of large Countreys presents a naturall remedy against couetousnesse, fraud, and violence. . . .[7]

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[18] Peckham, *A true Report*, in *Principal Navigations* VIII: 111.

[19] Brereton-Hayes, *ed. cit.*, 96.

[1] *Principal Navigations* VIII: 38.

[2] *Ibid.* VIII: 120.

[3] William Strachey, *The Historie of Travaile into Virginia Britannia*, 19. The argument from natural law is put this way: ". . . what soever God, by the ministration of nature, hath created on earth, was, at the beginning, common among men; may yt not then be lawfull nowe to attempt the possession of such lands as are voide of Christian inhabitants, for Christ's sake?" (p. 20). *Cf.* John Smith: ". . . if the heart and intralls of those Regions were sought: if their Land were cultured, planted and manured by men of industrie, iudgement, and experience; what hope is there, or what neede they doubt, hauing those aduantages of the Sea, but it might equalize any of those famous Kingdomes, in all commodities, pleasures, and conditions? seeing euen the very edges doe naturally afford vs such plenty, as no ship need returne away empty. . . ." *A Description of New England*, 1616, in *Works* I: 197.

[4] "Reasons and Considerations" appended to *A Relation, or Journal, of the Beginning and Proceedings of the English Plantation settled at Plymouth, in New England; by certain English Adventurers, both Merchants and others, etc.*, London, 1622, in Arber, *The Story of the Pilgrim Fathers*, 499–500.

[5] John Donne, *A Sermon vpon the Eight Ver[s]e of The First Chapter Of The Acts Of The Apostles*, 26, London, 1624.

[6] *General Considerations for the Plantation in New England*, (the so-called Higginson copy), in *Winthrop Papers* II: 118, Mass. Hist. Society, 1931.

[7] John White, *The Planters Plea*, 1630, in Force, *Tracts* II, no. 3: 2–3.

And nothing is more curious in the literature than to find Thomas Morton of Merry Mount fame accepting and enforcing the providential view of natural law:

> And herein this, the wondrous wisedome and love of God, is shewne, by sending to the place his Minister, to sweepe away by heapes the Salvages; and also giving him length of dayes to see the same performed after his enterprise was begunne, for the propagation of the Church of Christ.[8]

But the law of nature and the workings of Providence were reenforced by arguments from the Christian, and specifically from the Protestant, point of view. The English were the successors of the Chosen People, for whom a new Canaan had been appointed; this they were to possess peacefully, if they could—by force, if they must. Had not the ancient Jews slain the idolator? Had they not acted at the direct command of the Almighty? "*The land which we haue searched out*," Robert Johnson solemnly wrote, following Joshua, "*is a very good land, if the Lord loue vs, he will bring our people to it, and will giue it vs for a possession.*" [9] "Wee goe to liue peacablie," argued Robert Gray, "not to supplant" the Indians; yet Christian rulers may, if necessary, conquer the heathen by force of arms.[10] Crashaw waxed eloquent on the theme:

> The Israelites had *a commandement* from God to dwell in *Canaan*, we have *leaue* to dwell in *Virginea:* they were *commanded to kill* the heathen, we are *forbidden to kill them*, but are commanded to *conuert* them: they were *mighty* people, ours are *ordinarie:* they *armed*, ours *naked:* they had *walled townes*, ours haue scarce *houels* to couer them: that land flowed with *milke and honie*, our[s] abounds with as *good or better:* they sent men to search *that*, so we to search *this:* they brought of the *commodities*, so haue we: many *slandered* that countrey, so they doe ours: more *beleeued* the slander then the trueth, and so they doe of ours: yet some stoode boldly for the *trueth*, and so there doe in ours, and better then those that doe depraue it.[11]

And if the beginning was poor and small, Crashaw pointed out that the Israelites went down into Egypt but seventy souls and increased to six hundred thousand! God, said Cushman, no longer vouchsafes revelations, and consequently there cannot be "any land or possession . . . like unto the possession which the Jews had in Caanan; being legally holy, and appropriated unto a holy people"; nevertheless human life is a "wandering," and as Abraham and Lot, Paul and Barnabas sacrificed their friends and bodily comfort, so must "honest godly and industrious men" in New England.[12] Adam and Eve, thought Sir Robert Gordon, began the "pleasant worke to plant the Earth to succeeding posteritie," and the Jews, Spartans, Goths, Greeks, Romans, and his own contemporaries were but carrying out the divine commands.[13] John Cotton was even more specific.[14]

But the ethical sanction laid on the English was not merely the Old Testament command to increase and multiply; it was also the New Testament command to preach the gospel to all peoples—a theme which appears in travel literature from the beginning and which, because it accompanies, or is accompanied by, the profit motive, illustrates the complexity of the Tudor mind. To the Elizabethan or Jacobean Englishman there was no disharmony between the argument for gain and the argument for religious glory. God was to prosper His faithful, but their faithfulness could be shown only by obedience to His command; to deny this patent truth was to do the work of the devil:

> . . . such is the malice of wicked men the devils instruments in this our age, that they cannot suffer any thing (or at least few) to proceed and prosper that tendeth to the setting forth of Gods glory, and the amplifying of the Christian faith, wherein hitherto princes have not bene so diligent as their calling required. Alas, the labourers as yet are few, the harvest great, I trust God hath made you an

[8] Thomas Morton, *New English Canaan . . .*, Amsterdam, 1637, ed. C. F. Adams, Jr., 120, Prince Society, Boston, 1883. Morton's sarcasm shows how widespread was the argument.

[9] *Nova Britannia*, Force, *Tracts* I, no. 6: 10. The Jews, Johnson points out, were more glorious under imperialistic monarchs like David and Solomon, who replenished and enlarged their kingdoms (p. 15).

[10] *A Good Speed to Virginia*, [15, 16], London, 1609.

[11] W. Crashaw, *A Sermon Preached in London . . . 1609*, Sig F3 and verso, London, 1610. *Cf.* also Crashaw's adaptation of the argument from natural law, verso of D3.

[12] *Mourt's Relation*, in Arber, *The Story of the Pilgrim Fathers*, 496–497, 505.

[13] *Encovragements, For such as shall have intention to bee Vnder-takers in the new plantation of Cape Briton . . .*, Edinburgh, 1625, in Laing, *op. cit.*, the dedicatory epistle.

[14] Adam and Noah were told to multiply and replenish the earth, and God directs the migrations of people which follow. "This may teach us all where we doe now dwell, or where after we may dwell, be sure you looke at every place appointed to you, from the hand of God: wee may not rush into any place, and never say to God, By your leave; but wee must discerne how God appoints us this place." *Gods Promise to His Plantations . . .*, 1630, reprinted in *Old South Leaflets* III, no. 53: 7.

instrument to increase the number, and to moove men of power, to redeeme the people of Newfoundland and those parts from out of the captivitie of that spirituall Pharao, the devill.[15]

This was not the utterance of a Puritan preacher, but of a secular Elizabethan. "Preferring chiefly the honour of God" and having "compassion of poore infidels captived by the devill," Edward Hayes justified the failure of Gilbert's expeditions as being due to God's "judgments" on "ill disposed people" and pointed out in all honesty that

we could not observe the hundreth part of creatures in those unhabited lands: but these mentioned may induce us to glorifie the magnificent God, who hath superabundantly replenished the earth with creatures serving for the use of man, though man hath not used a fift part of the same, which the more doth aggravate the fault and foolish slouth in many of our nation, chusing rather to live indirectly, and very miserably to live & die within this realme pestered with inhabitants, then to adventure as becommeth men, to obtaine an habitation in those remote lands, in which Nature very prodigally doth minister unto mens endevours, and for art to worke upon.[16]

As for cheating the simple savages by trading on their ignorance, although the gospel was supposed to be "freely" preached, Sir George Peckham pointed out that heavenly riches would far outweigh the economic exploitation of the savages:

These heavenly tidings which those labourers our countreymen (as messengers of Gods great goodnesse and mercy) will voluntarily present unto them, doe farre exceed their earthly riches. Moreover, if the other inferiour worldly and temporall things which they shall receive from us, be weighed in equall balance, I assure my selfe, that by equal judgement of any indifferent person, the benefits which they then receive, shall farre surmount those which they shall depart withall unto us.[17]

"Then it is necessary for the salvation of those poore people which have sitten so longe in darknes and in the shadowe of deathe, that preachers should be sent unto them," wrote Hakluyt, who was certainly no hypocrite,[18] and if the Indians were "naked and unarmed, destitute of edge tools or weapons," the fact seemed to his contemporaries but a signpost of Providence for their conversion.[19] Let us be just: the first intent of the explorers, many of whom were sincerely horrified by reports of Spanish cruelty, was peaceful persuasion: the English must regard

principally, by what means the people of those parties may be drawn by all courtesy into love with our nation: that we become not hateful unto them, as the Spaniard is in Italy, and in the West Indies and elsewhere, by the manner of usage: for a gentle course without cruelty and tyranny best answereth the profession of a christian, best planteth the christian religion; maketh our seating most void of blood, most profitable in trade of merchandise, most firm and stable, and least subject to remove by practice of enemies. . . .[20]

Others, as they thought more realistically, argued that the Indians could not be converted "Apostolically, without the helpe of man" nor "meerely imperiallie, when a Prince, hath conquered their bodies, that the Preachers may feede their soules," but only "by way of marchandizing and trade," the English to buy "the pearles of earth" and sell "the pearles of heauen."[21] Nor was this point of view confined to secular men; the Reverend Alexander Whitaker, viewing an Indian rain dance, was led to meditate on the intention of Providence with reference to the heathen:

All which things make me thinke that there be great witches amongest them and they very familiar with the divill. I should more admire Virginia with the Inhabitants yf I did not remember that Egipt was exceedinge faithfull, that Canaan flowed with milke and honey before Israel did overrunne it, and that Sodom was like the garden of God in the dayes of Lott. Only I thinke that the Lord hath spared this people and inriched the bowells of the Country with the riches and bewty of Nature that we wantinge them might in the search of them communicate the most excellent merchandize and treasure of the Gospell with them.[22]

[15] *A letter written to M. Richard Hakluyt of the Middle Temple, conteining a report of the true state and commodities of Newfoundland, by M. Anthonie Parkhurst Gentleman*, 1578, in *Principal Navigations* VIII: 9–10.

[16] *A report of the voyage and successe thereof, attempted . . . by sir Humfrey Gilbert*, in *Principal Navigations* VIII: 60.

[17] *A true Report*, in *Principal Navigations* VIII: 119–120.

[18] *Discourse of Western Planting, ed. cit.*, 8.

[19] Brereton-Hayes, *Brief and True Relation, ed. cit.*, 99. ". . . no nation of christendom is so fit for this action as England. . . ."

[20] "Inducements to the liking of the Voyage . . . by M. Richard Hakluyt the elder" (1585) in *do.*, 111. Hakluyt demands "some ancient captains of mild disposition and great judgment be sent thither." Is this an echo of Irish failure?

[21] *A Trve Declaration of . . . Virginia*, 1610, Force, *Tracts* III, no. 1: 5–6.

[22] Letter to Crashaw from Jamestown, August 9, 1611, in Brown, *Genesis* I: 499. See also his *Good Newes from Virginia, passim*, London, 1613.

So long as the Indians did not resist conquest the ethical problem was simple,[23] and invasion could even be justified as protection of gentle people against more bloodthirsty foes. But it soon appeared that the Indians would "steale any thing comes neare them; yea, are so practized in this art, that, lookeing in our face, they would with their foot, betweene their toes, convey a chizell, knife, percer, or any indifferent light thing," from which it was natural to argue that "they are naturally given to trechery";[24] their "assaults and Ambuscadoes"[25] were as characteristic as those of the wild Irish; and the necessity of explaining the natural disinclination of the natives to surrender their country to the newcomers led to some interesting exercises in ethical casuistry. One viable explanation was obvious: the Indians were the children of the devil, a being whose jealousy had been excited by the coming of the Christians—to slaughter them was therefore but to defeat Satan: "Remember the end of this voiage," exclaimed the Rev. W. Crashaw, "is the destruction of the diuels kingdome,"[26] and the devil was no passive adversary. "This bootlesse voyage," declared a colorful passage in the *Wonder-Working Providence of Sions Saviour*,

> incouraged the Indians very much, who insulted over them at the fort, boasting of this their deluding them, and withall, they blasphemed the Lord, saying Englishmans God was all one Flye, and that English men was all one Sqawe, and themselves all one Moorhawks. Thus by their horrible pride they fitted themselves for destruction. The English hearing this report, were now full assured that the Lord would deliver them into their hands to execute his righteous judgment upon these blasphemous murtherers. . . ."[27]

But the logic of the Pequot War was nothing new. The voyagers had said the same thing, as Christopher Levett observed:

> They are very bloudy minded and full of Tracherie amongst themselues, one will kill another for their wiues, and he that hath the most wiues is the brauest fellow: therefore I would wish no man to trust them, what euer they say or doe; but alwaies to keep a strickt hand ouer them, and yet to vse them kindly, and deale vprightly with them. . . .[28]

Johnson justified war; Levett counselled peace—but were the Indians to be dealt with as living in "ciuil pollitie," or not? If they were not under the law of nations (and Smith sometimes seemed to think they were not), let them be thankful the English were not the Catholic Spaniards:

> Those temporall proceedings [towards the Indians], to some maie seeme too charitable, to such a dailie daring trecherous people; to others vnpleasant that we washed not the ground with their blouds, nor shewed such strange inventions in mangling, murdering, ransaking, and destroying (as did the Spaniards) the simple bodies of those ignorant soules; nor delightful, because not stuffed with relations of heaps and mines of gold and siluer, nor such rare commodities as the Portugals and Spaniards found . . . we chanced in a lande, even as God made it. Where we found only an idle, improvident, scattered people, ignorant of the knowledge of gold, or silver, or any commodities; and carelesse of anything but from hand to mouth, but for bables of no

[23] ". . . over and beside the knowledge how to till and dresse their grounds [the Indians] shal be reduced from unseemely customes to honest maners, from disordered riotous routs and companyes to a well governed common wealth, and withall, shalbe taught mechanicall occupations, arts, and liberall sciences; and which standeth them most upon, they shalbe defended from the cruelty of their tyrannical and blood sucking neighbors the Canibals . . . by this meanes many of their poore innocent children shall be preserved from the bloody knife of the sacrificer, a most horrible and detestable custome in the sight of God and man, now and ever heretofore used amongst them." Peckham, *A true Report*, in *Principal Navigations* VIII: 120.

[24] Capt. Newport's Discoveries, Virginia (A Relatyon of the Discovery of our River, from James Forte into the Maine; Made by Capt. Christopher Newport, and sincerely written and Observed by a Gentleman of the Colony), *Archaeologia Americana* **4**: 64.

[25] Smith, *Works* I: 92.

[26] *A Sermon Preached in London . . . 1609*, folio B4. The principal end of the Jamestown settlement was officially declared to be "*first* to preach and baptize into *Christian Religion*, and by propagation of the *Gospell*, to recover out of the armes of the Divell, a number of poore and miserable soules, wrapt up unto death, in almost *invincible ignorance;* to endeavour the fulfilling, and accomplishment of the number of the elect . . ." (quoted in Brown, *Genesis* I: 339). *Cf.* Robert Johnson, *The New Life of Virginea*, Force, *Tracts* I, no. 7: 18. The Indians, according to Whitaker, were "naked slaues of the diuell," (p. 24), and the weapons of the Prince of Darkness are covetousness, jealousy, mutiny, fornication, profaneness, idleness, etc., all of which were employed both within the colony and against it; nevertheless, the Indians have reasonable souls and civil government and can be converted. "If we were once the masters of their Countrey, and they stoode in feare of vs (which might with few hands imployed about nothing else, be in short time brought to passe) it were an easie matter to make them williugly [*sic*] to forsake the diuell. . . ." *Good Newes from Virginia*, 23, 24, 25–27, 40, London, 1613.

[27] Edward Johnson, *Wonder-Working Providence of Sions Saviour* (1654), ed. J. F. Jameson, 164, New York, 1910.

[28] *A Voyage into Newv England*, in Baxter, *Christopher Levett, of York*, 117.

worth; nothing to encourage vs but what accidentally wee found nature afforded. . . .[29]

So likewise argued the stately John Winthrop:

That which is common to all is proper to none. This savage people ruleth over many lands without title or property; for they inclose no ground, neither have they cattell to maintayne it, but remove their dwellings as they have occasion. . . .[30]

But if the Indians lived under the law of nature, if they enjoyed civil government, then it was lawful to enforce treaties made with them:

What injury can yt be to people of any nation for Christians to come unto their ports, havens, or territoryes, when the lawe of nations (which is the lawe of God and man) doth priviledge all men to doe soe, which admitts yt lawfull to trade with any manner of people, in so much as no man is to take upon him (that knoweth any thing) the defence of the salvadges in this point, since the salvadges themselves may not impugne or forbid the same, in respect of common fellowship and community betwixt man and man. . . .[31]

The Virginia Council therefore dwelt with ethical pride upon the fact that they had entered into lawful treaty with "Paspehay" for the purchase of land, and argued it was not unlawful to snatch the sword out of the hands of a madman (i. e., take even more land),

So that if just offences shalt arise, it can bee no more iniustice to warre against infidells, than it is when vpon iust occasions wee warre against Christians. And therefore I cannot see, but that these truths, will fanne away all those chaffie imputations, which anie Romish boasters (that challenge a monopolie of all conuersions) will cast vpon it, or any scrupulous conscience can impute vnto it.[32]

And the New England mind dwelt with equal complacency upon the fact that Massasoit, "the imperial Governor," acknowledged the supremacy of King James and by "a joint consent, hath promised and appointed us to live at peace, where we will, in all his dominions. . . ." Besides, the land was "a vast and empty chaos." [33] We English must do as we have been done by; and if the ancient Romans converted the ancient Britons to "*ciuilitie*," let the English here repay the debt,[34] especially since the papists were misrepresenting the situation—"I would not one, seasoned with the least taint of that leauen, to be setled in our plantation, nor in any part of that country," as Robert Johnson exclaimed.[35] And as a curious footnote to these ethical sanctions for invading the lands of another people, one may watch Sir William Alexander turning the marriage of Pocahontas and John Rolfe into a justification for the white man's treatment of the red:

Lawfull allyances thus by admitting equalitie remoue contempt, and giue a promiscuous off-spring extinguishing the distinction of persons, which if that People become Christians, were in some sort tolerable, for it is the onely cause that vniting minds, free from jealousies, can first make strangers confide in a new friendship, which by communicating their bloud with mutuall assurance is left hereditary to their posteritie.

Following this interesting passage, he discusses the Indian massacres at Jamestown![36] But perhaps it remained for a more cynical age to see the inconsistencies of the Tudor mind in this regard; for the most part the contemporaries of Smith, Myles Standish, and Lord Baltimore were content with the conclusion of John White in *The Planters Plea:*

. . . if in the Worlds infancy, men out of an ambitious humour, or at present for private advantages and expectation of gaine, thrust themselves out from their owne dwellings into parts farre remote from their native soyle; why should not we conceive, that if they doe this for a corruptible crowne; that the desire and expectation of an incorruptible . . . may as strongly allure such as by patient continuance in well-doing, seeke immortalitie & life?[37]

Even a Thomas Morton was susceptible to promotional enthusiasm; and as this study began with an appeal to Renaissance *virtù*, it may well conclude with the unexpected tribute by a genial

[29] John Smith, *The Proceedings of the English Colonie in Virginia (1606–1612)*, in *Works* I: 147–148.

[30] "General Observations," *Winthrop Papers* II: 120. He goes on to argue that Christians have warrant to occupy waste lands, following Biblical precedent.

[31] William Strachey, *The Historie of Travaile into Virginia, ed. cit.*, 16. ". . . if traffique be thus justifiable (which intended nothing but transitory profitt and increase of temporall and wordly goodes) shall not plantinge the Christian faith be much more?"

[32] *A Trve Declaration of . . . the Colonie in Virginia*, Force, *Tracts* III, no. 1: 7.

[33] *Mourt's Relation*, in Arber, *op. cit.*, 500, 501.

[34] W. Crashaw, *A Sermon Preached*, folio C4 verso.

[35] *Nova Britannia*, Force, *Tracts* I, no. 6: 20.

[36] *The Mapp and Description of New-England*, 28, 1630, in Laing, *op. cit.*

[37] In Force, *Tracts* II, no. 3: 45.

son of this world to the glamor of the Promised Land:

If art and industry should doe as much
As Nature hath for Canaan, not such
Another place, for benefit and rest,
In all the universe can be possest.
The more we proove it by discovery,
The more delight each object to the eye
Procures; as if the elements had here
Bin reconcil'd, and pleas'd it should appeare
Like a faire virgin, longing to be sped
And meete her lover in a Nuptiall bed,
Deck'd in rich ornaments t'advaunce her state
And excellence, being most fortunate
When most enjoy'd: so would our Canaan be
If well imploy'd by art and industry;
Whose offspring now, shewes that her fruitfull wombe,
Not being enjoy'd, is like a glorious tombe,
Admired things producing which there dye,
And ly fast bound in darck obscurity;
The worth of which, in each particuler,
Who list to know, this abstract will declare.[38]

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[38] *The New English Canaan*, 1637, *ed. cit.*, 114, "The Authors Prologue."

THE USE OF COLOR IN LITERATURE

A Survey of Research

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(*Read in part April 22, 1944*)

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PREFACE

THE use of color in literature has been the subject of systematic studies for almost a century. The research work devoted to the field during this period is surprising in volume, and displays a fruitfulness of ideas and a variety of approach which are of interest far beyond the subject itself.

At the same time, however, the work displays an almost total lack of coordination. Color history has always been the hunting ground of dilettantes; and even the serious scholars have mostly remained isolated within their national literatures and their particular branches of learning. Many investigations have been carried through without knowledge even of the fundamental studies in the field. Methods, which were long ago tested by others, have been painfully worked out from anew. Comparative studies have been rare, and the results heterogeneous. There is much truth in Goethe's maxim about all the good and clever work which exists simultaneously on this earth but "never gets in touch."

This article intends to serve a better coordination by bringing together the material and surveying what has been done.

The attempt naturally does not aim at anything like completeness. Color research is carried on intensively within many fields of knowledge, from physiology to the history of religion; no scholar could possibly cover the whole area. Even within literary history the material is overwhelmingly rich and not always easily accessible. The article only pretends to serve as a first guide, enabling other research workers quickly to acquaint themselves with the general background of facts and methods which have bearing upon the subject. Within the border lands (psychology, history of civilization and art, folklore, etc.) the material is presented without pretensions, as suggestions for further study. Within literary color research proper an attempt has been made to give a representative picture of the various ways of approach, grouped around the main periods, styles, and authors, but without any illusions of having exhausted the material. The first chapter surveys the research methods and their development. In the second chapter the more important results are sketched within the framework of color history.

The bibliographical collections at the end of the article are arranged systematically (the authors by language). The classification is somewhat rough, but the index of names will make it easy to the reader to find his way. Figures in parenthesis in the text refer to the numbers in the bibliography; the titles are in most cases given *de visu*. A summary of each

item would have made the bibliography too voluminous, but in brief notes I have pointed out a few studies which offer a more extensive analysis. When a book has already been discussed in the text, the summary is usually not repeated in the bibliography. In selecting the titles I have been less critical with regard to writers who have been sparsely investigated than in cases where the material is abundant.

The article is focussed on color vision, but also includes some material with bearing upon the other senses and sensation generally.

The material for the survey was collected from the early 1920's on, more systematically during 1935–1936 and 1938–1939; the manuscript was roughly drafted in the latter year for an academic competition. Before I had time to revise the draft and exhaust the collected material my homeland Norway was invaded by the Germans. While I managed to bring to the United States a copy of the draft manuscript, the entire material was held up in Japan and probably lost in the bombing of Kobe. Within a reasonable future I will not be able to devote more time to the subject. I have therefore gratefully accepted the offer of the American Philosophical Society to print the manuscript as it is, with a few additions and corrections, before it becomes too dated.

For these reasons the article appears in a less perfect shape and as a whole is much more superficial than I had hoped in happier times. Some subjects or periods are discussed quite perfunctorily (for instance, theoretical aesthetics) or hardly at all (Dutch, Slavonic, and Oriental literatures); the American field also would have deserved a more thorough treatment. Some books and articles were unavailable to me in spite of extensive hunting; material published since 1938 I could not survey systematically. Being printed from a copy, not from the original cards, the bibliographical collections may have minor errors; a complete recheck was impossible. I hope that these shortcomings will not seriously reduce the practical usefulness of the article.

I gratefully acknowledge the support given to my studies by grants and fellowships from Oslo University, Houens Legat, and Nansenfondet. Among the European scholars who have volunteered their assistance in one way or another I mention especially Harry Andersen, Copenhagen, for his helpfulness in the field of Scandinavian stylistics. On this side of the Atlantic, G. Chinard (Princeton), St. Einarsson (Johns Hopkins), E. Haugen (University of Wisconsin), Th. H. Johnson (Lawrenceville School), H. A. Kenyon (Ann Arbor), D. M. Robinson (Johns Hopkins), and John W. Spargo (Northwestern University) have kindly read parts of the manuscript and added about a dozen titles to the bibliography. An indebtedness of a particular kind I feel toward some great libraries: the Library of the British Museum in London, the Bibliothèque Nationale in Paris, the Universitätsbibliothek and the Bayerische Staatsbibliothek in Munich, the Library of Congress in Washington, D. C., the New York Public Library in New York, and above all the Bibliothèque de la Sorbonne in Paris and the Universitetsbiblioteket in Oslo. These libraries and their staffs have in countless ways facilitated my studies, during a period of the past when research on an international scale was still possible.

I. PROBLEMS AND METHODS

The colors—and their cousin the light—are one of the most conspicuous elements in the physical world, to such an extent that their total absence is most unusual. They are entwined with the emotional and intellectual life of man in countless ways, and have always been an important element of human culture. From the very beginnings they played a part in religion and magic, rites and symbolism, and in the entire material civilization. They were used consciously in primitive painting and sculpture and in the first attempts of poetry. Relatively early speculations arose relating to their importance as a physical element, and attempts were made to formulate a color theory. But the psychological and historical understanding of the nature of the colors is a late development. Only by a slow and inconsistent growth man has realized their relations to himself. Methodical research is hardly to be found before the middle of the nineteenth century.[1]

In Greek and Roman antiquity the physical and philosophical aspects of the problem were still predominant. Attention was focussed on the role of the colors in the universe and their value as symbols of immaterial principles (Plato; Aris-

[1] Surveys of the psychology of vision through the ages are made by Boring (4) and Klemm (25, p. 289–307); scattered remarks to color history are to be found in Bosanquet (5, *passim*) and *Dictionary of Philosophy and Psychology* (11, *s.v.* Color and Vision). Considerable material is brought together in Goethe's *Farbenlehre* ("Materialien zur Geschichte der Farbenlehre" and the supplement "Polemischer Theil").

totle; Plotinus). Early the ancients also began to speculate in general terms on the aesthetic importance of the colors, especially with regard to the law of symmetry (Augustine). They played a certain part in the theoretical discussion of literary description ("ut pictura poesis") which in some points, at least, touched upon the sense impressions and was to be of increasing importance later on. But systematic literary analysis was not to be found in this field more than anywhere else in Classical antiquity. The Middle Ages took over a considerable part of the classical ideas through Dionysius Areopagita, developed them further in mystic speculation, and incorporated them into the theological systems (Thomas Aquinas, the liturgical color canon). But there was no new understanding of the problem.

The Renaissance saw an eruption of spontaneous delight in colors which deeply influenced both poetry and art and left its mark even on theory. Some of the color tracts from the Italian schools of painting (Leonardo, Leone Battista Alberti) touched upon the problem of color combinations in a way which anticipated much later discoveries. The new school of textual criticism also approached the problem from new angles. But there was little more than attempts and beginnings. Still physics and natural philosophy played the main part, often with a strong inmixture of fantastic speculation (Paracelsus).

From the seventeenth century on the problem was gradually approached on a different level. The new science of optics changed the emphasis from physics to physiology, from color in itself to color as a stimulus to the human soul. Thus the first foundations were laid for a deeper interpretation even of the expression in literature and art. Simultaneously a color study began to develop which for lack of a better name might be ascribed to the "history of civilization"—a confused kind of research, often originating from practical demands and inspired by a planless interest in curios, but not without value. The interest remained amateurish and sporadic, however; and the periods of Classicism and Enlightenment lacked interest both in the problems of color and in the colors themselves. The real change was only brought on by the great pre-Romantic wave after the middle of the eighteenth century.

The wakening interest was noticeable soon after 1750, for instance in the vivid speculation on the phenomena of synaesthesia (the "color organ") and in J. A. Eberhard's attempt to analyze the emotional value of the individual colors (1774). But the innovator was Goethe. The optical and physiological parts of his color theory have long ago been discarded by science. But in the chapters concerned with what he called "the sensuo-ethical effect" Goethe touched upon problems of research which were to be approached in earnest only a long time afterwards. Thus, he is the first to broach in a systematic way the study of color harmony and its extremely complicated background. And all the time Goethe saw the colors as part of a vast picture, connected, not only with physiological theory, but with the whole historical entity of culture. In his scattered notes on the subject optics and theory of art are closely linked to philology and history of civilization. That many-sided analysis of the color as an element of life which is now the program of research he anticipated in its outlines.

This notwithstanding, Goethe cannot justly be called the founder of literary color analysis in the scholarly sense. He lacked method; he mostly moved in the border regions or contented himself with generalities. Unexpectedly the same also holds good of his satellites and antagonists, the Romanticists. In their own literary creation color experienced a break-through never paralleled before; and at the same time they became the real founders of the history of literature. But a thorough method was not born from their efforts. The color chapters in their aesthetic writings are more interesting as documents of mystic speculation and personal taste than as specimens of research work. That combination of poetic sensitivity and scientific approach which was the distinguishing mark of Goethe was lacking altogether in the Romantics; and this still more held good with regard to the philosophizing schools of literary history which succeeded them during the first part of the nineteenth century. Scattered studies on color history saw the light in this period; but the writers seldom posed the problem clearly. No contact was established with the new victorious school of historical research nor with the quickly developing discipline of optics. It was only after the middle of the century that all the trends of research were welded together into a new branch of knowledge, by the rising school of Positivism.

The decisive stimulus came from Classical philology: the famous controversy on Homer's use of color which is linked to the name of the

British statesman and amateur scholar William Gladstone. The meticulous old school of philologists had skirted this problem more than once before. As early as in 1557 Scaliger pointed to the puzzling vagueness of the color words in the ancient writers, and Doering (280) touched on the same phenomenon in 1788. Goethe discussed the Greek color terms at some length, and around the middle of the nineteenth century several dissertations appeared which were more or less concerned with landscape description and use of colors in Classical antiquity.[2] But Gladstone began an epoch because he gave the question a pointed and sensational form which went far beyond the border lines of Classical philology and drew the problem into the focus of international scholarly debate.

There is no reason to make any detailed survey of the great Homer controversy. In all decisive points the struggle has long ago been decided in Gladstone's disfavor.[3] But the way in which the battle was fought and the breadth which the discussion gradually assumed were of the greatest importance to the development of the discipline. Gladstone's starting point was that absence of certain color shades in Homer as compared to modern poetry, which had already been noticed by scholars before. But while the old philologists explained the phenomenon as a general primitive trend, based on "austera rudium illorum hominum simplicitas" (Doering), Gladstone concluded that the reason was an anomaly of the eye, a real color blindness. By statistics he tried to prove that Homer's power of color discrimination was so undeveloped as to make his eye perceive almost exclusively the shades from light to shadow.

This idea was presented for the first time in Gladstone's great Homer book of 1858 (315), and as early as in the 1860's the theory aroused some discussion, but mostly among philologists. The debate entered a wider stage around 1870 when the hypothesis was adopted by German systematists of evolution. L. Geiger (313–314) began the generalization. He maintained that, not only was Homer himself color blind, but in this respect he was typical of a general stage of historical development: in all peoples color perception and color vocabulary developed slowly from the same imperfect beginnings in a certain sequence which can be followed in the old literatures and is repeated everywhere. According to Geiger, it was up to the new school of exact science to find the laws of nature governing these changes, in close cooperation with philology: "The time has come when linguistics and physics must join their forces because their aims are common." This appeal was headed by the ophthalmologist H. Magnus (326), who outlined a slow development of the physiological color sensitivity in historical times, identical in all peoples, and documented by rich material from ethnography.

These hypotheses let loose an extensive and heated debate which partly lasted into this century; and the very starting point made the exchange of opinions broad and comprehensive. The first great counterblow, Allen's book of 1879 (310), not only used to the widest extent the results of physiology and comparative zoology, but also brought together a huge amount of additional material from ethnography and an almost equally extensive documentation from the comparative history of art. Finally, in chapter XIII of his book Allen also gave a detailed analysis of the problem from the point of view of philology and literary history, with numerous examples from modern writers. Almost equally comprehensive were the other great contributions, Schultz' polemic writings in favor of the theory (303) and Bénaky's (278), Hochegger's (318), and Veckenstedt's (304) books against it, let alone the series of articles and pamphlets.[4] As late as in the 1930's Pérez de Barradas (121) refuted the hypothesis with tremendous learning drawn from modern archaeology, ethnology, and history of art. The problem, which from the outset bore only upon a minor detail in the work of one Classical author, thus was linked to many other branches of learning and discussed from the most various angles, with anchor ground in the solid method of Classical philology, but with the wide horizon of the self-confident theorists of evolution.

[2] Jacob 1839 (349), Göbel 1855 (317), Cope 1856 (287), Marg 1857 (283), and others.

[3] Extensive bibliographical collections, all incomplete, but partly supplementing each other, are to be found in the books of Allen (310), Euler (312), Körner (322), Marty (327), and especially Hochegger (318) and Schultz (303).

[4] Ethnological color literature is listed by Hochegger (318), Katz (24, p. 5), and especially Parsons (34). See also Andree (41), Gatschet (48), Kirchhoff (53), Magnus (57–58), and Strauss und Torney (277), all of whom had their starting point in the Gladstone controversy. A modern example: Hess (51). Philological studies linked to the controversy are listed in the bibliography under Homer; for other fields see especially Delitzsch (270–271), Furrell (272), Hopkins (274), Veckenstedt (491), and Weise (66).

Further support came from developments within the science of color itself which also began around 1880 and swiftly grew in strength. In place of the previous psychological speculations which had been loose and lacking in method, Fechner in 1876 founded the science of experimental aesthetics. By exact observation of thousands of experimentees he and his school tried to define in general formulas the human reaction to the colors and color combinations, collaborating partly with psychophysics, partly with the new psychology of association.[5] In a field which once appeared as the playground of mere chance clear laws thus gradually seemed to emerge giving the colors their appropriate place within the close-knit system of science, whether they appeared in art or poetry. The consequences of these views were drawn by a sensualistic theory of art which consciously made the sense perception a driving power in all aesthetic creation.

From many directions the colors were thus drawn into the focus of scholarly attention during the 1870's and 1880's as an intersecting point of science and the humanities. Gradually the various research disciplines followed the call and began to develop their own professional methods in accordance with the new principles.

The trend is least perceptible within that lawless frontier district, the "history of civilization." As mentioned above, color studies of this type date centuries back, especially the investigations pertaining to symbolism, mythology, and liturgics,[6] and the more profane color research can boast of a pedigree as well. Such work was carried on all through the century;[7] and both before and after 1870 the offered material often had the character of "nicknack," gathered without any method whatsoever.[8] But gradually, the influence of systematic research made itself felt. Several large-scale compilations were published;[9] there was a growing tendency toward generalization and a new understanding of the historical period as an entity where all aspects are interrelated. The most significant experiment was perhaps Ewald's attempt to write the "inner history" of the color yellow all through human history (95), a highly premature summing-up which was later thoroughly refuted by Volbehr (139), but which still appears with approval in the writings of Havelock Ellis.

The connection with the "spirit of the times" was still more evident in philology. Here, too, there were elder investigations to build on, as we have seen,[10] but systematic research came now. The work was directly inspired by the Homer controversy and often had its starting point in details of the debate. To the linguists of the new positivistic school life's delight was to collect vocables, lay down their etymology, and trace their semasiological ramifications; and the color words offered a suitable material. Within most of the great languages the philologists now carefully worked through the general words of apperception[11] and the specific vocables of the various senses, particularly the color words. Their age was established, their development studied, and their meaning analyzed. This work partly continued after 1900.[12]

A corresponding attitude gradually developed within literary history proper. Scattered observations of the function of the sensory impressions in poetry may be found as early as in Sainte-Beuve, and considerable material was brought to the light during the Homer controversy. But it was Taine and his school who arranged it under the new aspects; in his literary method the sensory perception played a decisive part. Taine's dominating idea, which was to influence scholarly thinking deeply, often without being formulated in words, was the conviction that what makes a poet is "l'afflux violent des sensations," and that there is a close and traceable connection between this sensory impact and its literary expression. To the new school of psychology the apperception of colors and the reaction to them by emotions and thought were

[5] Bibliographical material for the earlier periods of experimental aesthetics is presented by Lalo (28) and Larguier des Bancels (29), and for the whole field by Chandler and Barnhart (9). I disregard here the great aesthetic systems which often discuss the colors extensively; they have been of little importance to literary history.

[6] A series of elder works, especially from the sixteenth and seventeenth centuries, are listed by J. W. Legg (112) and Thebussem (407); compare Gimma (99).

[7] Bruchmann (86), Creuzer (90), Delitzsch (91), Portal (122), Lange (111).

[8] See for instance Cassel (87).

[9] See for instance Auber (76), Braun (83), and Weinhold (140).

[10] See above, p. 166, and among later attempts for instance Roesler 1868 (60) and Boehmer 1872 (43).

[11] Main works Grimm (49) and Bechtel (42). Numerous special studies of the same kind are omitted here; they have only indirect interest to our subject.

[12] A sketch of the whole field of word history, with bibliography, has been given by Grundtvig (50); see also the bibliography below, chapter B. Especially comprehensive are the works of Jodin (52), Ott (458), and Schwentner (62).

regulated by simple laws which would soon be laid down in detail; and the impressions were reflected in the aesthetic creation in the same simple way. It is possible to go back from the work of art or poetry to its origin in the sensual world by a series of clear conclusions. One may exhaustively describe and define a poem, for instance, by summing up the impressions on which it is built, only taking into account that they are modified and refracted through the individual personality and the given surroundings.

Especially clear formulations of these views with their strong scientific confidence may be found in É. Hennequin's program for what he called the "esthopsychology" (190–1888). "Il n'est pas actuellement de particularité esthétique importante qui ne puisse aboutir à la désignation d'une particularité psychologique définie, qui, à son tour, peut être exprimée en une altération définie du mécanisme général de l'entendement. On sait aujourd'hui, grace aux belles systématisations de Spencer, Wundt, Taine, Bain, Maudsley, ce q'est un esprit humain, quelles sont ses parties et de quelle façon elles coopèrent." From the works of a genius we can construe the form of his brain; Victor Hugo certainly had especially rich gyri in "la troisième circonvolution frontale." In this simple system the apperception of colors takes its place as an important means of classifying the organic disposition: "l'interprétation . . . est fort aisée en pratique."[13] Similar views, only less grossly formulated, were accepted as a matter of course by numerous contemporary scholars.

As had to be expected, psychiatrists and other medical men played a great part in the literary research work which tried to realize this program: the ties between body conditions and literary expression seemed to be most tangible in the pathological case. The roughest generalizations were due to the Lombroso school with its background of anthropology and criminalistics (30). A more direct influence on literary history can be traced to the work of Éd. Toulouse. He began in protest against the cheap results of Lombroso, but in their basic principles the two were not much at variation. This is obvious in Toulouse's famous psychophysical examination of the living Émile Zola (591), from the fingerprints to the urine, with thorough discussion of the novelist's whole apparatus of sensation and with interesting details (p. 159) on his ability of distinguishing and remembering the colors. Similar lines were followed in the psychological investigation of living poets which was begun about the same time by the psychologist Binet and his students (176). A long series of "psychograms" was published, from the 1880's on deep into this century, dissecting the poets with the instruments of physiology and psychiatry.[14] The investigations usually displayed a triumphant delight of discovery, and sometimes the details were really of interest to the analysis of the color sense, at least as a background. But most of these books are rattling skeletons rather than living portraits. Among color studies by professional literary historians Nayrac's book on La Fontaine (543) is directly inspired by the ideas of Toulouse without yielding very substantial results from a literary point of view. On a different level is Mabilleau's study of Victor Hugo to which we shall return.

Similar ideas made themselves felt within the more traditional literary history, in a new zest for the establishment of literary "facts" and "laws." "Stoffgeschichte" became the watchword of the time. Here, at least, there were literary data which seemingly could be treated according to the methods of science; with untiring accuracy fiction and poetry were sifted and catalogued from the point of view of subject matter and literary topics. As yet, the colors were mostly treated as accessory in these studies. But in many fields they naturally belonged in the picture, and more or less was also registered about the traditional trends and patterns of color description and color fashion, and the shifting color trends of material civilization. The most energetic work was devoted to the description of landscape. The beginnings date back as far as the 1860's, but the analysis did not really get under way till after 1880.[15] Many of the investigations, both then and later, merely discussed the general background for the description and the attitude toward nature in a more philosophical sense. Still more of these earlier works are so vague and lacking in method that the few color details have little or no value.

[13] Hennequin, p. 3, 71 ff., 86 ff., 236.

[14] There is no reason to list them in this survey. A bibliography is to be found in K. Schneider's book (198).

[15] Several early studies are quoted by Engel (653); more recent books are listed by Goetz (206) and Kammerer (815). Quite important to the development of the discipline were the popular surveys of the German scholar Biese (202, 249, 279). No general bibliography can be given here, desirable as such an undertaking would be.

But in the analysis of the descriptive technique of individual poets there is once in a while some material of real interest. For instance, some of the first attempts to link the analysis of literary and pictorial description were made in this field.[16]

In some of the studies there was also a useful debate from the point of view of science. Especially important is the famous analysis of landscape description which is due to the geographer Ratzel (213). In a most instructive way he made the colors appear as a part of the landscape in the physical and geographical sense and discussed the means and ability of language to make these aspects clear to the reader. Equally instructive were his analyses of the play of colors in the clouds (212) and Pollock's corresponding studies of the water (211); Minnaert (210) and Thoene (214) later worked along similar lines. Another difficult and important field was touched upon by Geikie (205) and Gradmann (207) who tried to follow the changes in the physical surroundings of man throughout the ages and trace the possible influence of these changes on his attitude toward landscape and landscape description.

Much work was also devoted to the analysis of what the period called literary style: the use of images, metaphors, and vocabulary, particularly the epithet. Here as before the discussion of the colors often was a mere by-product from investigations for other purpose, or was lacking altogether; and too many of these books were piles of dead observations which told nothing about the literary personality. Quite especially this holds good for the countless metaphor studies of the German school; usually they were arranged catalog-wise according to subjects of comparison, and no attention was paid to the sense impressions as a source of the imagery.[17] Nevertheless some valuable material was brought together in these books. The historical background often was worked out with much care and the material treated with the traditional severity of the philologist. A good example is Venturi's huge collection of parallels to Dante's imagery (387).

Even if, generally speaking, these studies were more or less "positivistic" in their approach, they were not necessarily dogmatic. Gradually the color research was bound to raise fundamental questions with regard to the actual interplay between the sense impressions and literary creation, between sensation and words of sensation, between the isolated epithet and the impression as a whole. In the long run these problems could not be solved by postulates; and many of the arguments touched upon in the discussion far exceeded the scientific theories of the 1880's and anticipated the debate after 1900. The cheapest generalizations of the outsiders were met with criticism from the very beginning or were presented with some hesitation by the inventors. Toulouse himself once made the thoughtful remark that Zola's sense of smell, while being exceptionally sharp, proved not to have been quantitatively beyond the average, but rather somewhat below, and that consequently the tremendous importance of the sensations of smell in Zola's poetic world must be due to "memory and the way in which the psychological material is being used," more than to mere physiology.

Similar far-reaching ideas were worded in the discussion of that hypothesis which aroused the most widespread interest in the field before 1900: the theory of the psychiatrists Sergi and Patrizi of Lombroso's school that the amazingly one-sided color scale in the works of Leopardi was due to abnormal conditions in his eye (393–394). In their replies Graf, Hauvette, and Manacorda (390–392) pointed to factors of psychology and considerations of style as the real explanation more than simple physiological facts: "subordinazione del senso al sentimento e all'intelletto, . . . indeterminazione nel discritto, ma non povertà del sentito." In the eloquent program for a literary color history of the world which was sketched in 1896 by the psychologist Havelock Ellis (183) there were certainly some characteristic remarks about the poets who "instinctively record the impressions they receive from the external world."[18] But in the main Ellis drew a line of demarcation between physiology and literary creation with much understanding of the special difficulties involved in an analysis of the aesthetic process.

In the best studies from the period, moreover, the new methods were applied with a genuine understanding of poetry which may use even dogmatic theories for good purpose. The most

[16] See for instance Woermann's study of Greek and Roman landscape description (286).

[17] A bibliography of this immense field is given by Hüttig (812), and for Greek and Roman literature by Assfahl (359).

[18] The study is directly inspired by Pouchet's naïve article on Homer (330).

important work was due to English and French scholars. The years just before and after 1900 saw the publication of as many-sided and keen analyses as Mabilleau's studies in the colors of Victor Hugo (532–533), Morel's book on J. Thomson (764), and Sweet's analysis of Shelley (743). Kutscher's careful description of the background of Goethe's color terms also fits into the picture (925). There was even an attempt of a more comprehensive synthesis, Pratt's excellent work on the colors in English Romanticism (630), which combined exact statistical analysis with sound poetic understanding, in conscious reaction against the cheap generalizations of the psychologists.

If the bulk of the color studies before 1900 are taken into consideration, however, the impression is mixed. Many important factors were drawn into the picture, psychological, historical, and literary. Their interplay was analyzed with great seriousness of method; these conscientious scholars kept clear of the loose slang of the littérateurs. But too often there was something mechanical and superficial about their work. They frequently contented themselves with arranging the psychological facts by heads and columns in a kind of "poetic police-description" instead of trying to penetrate into the mysterious depths of the creative mind. The various means of literary expression were defined and grouped, but they did not always work together in the analysis as they do in the living poetical work, and were rarely interpreted as reflections of a personality. The description of the historical background often did not go beyond the accumulation of unrelated facts and was seldom vitalized by a *vue d'ensemble*. Not only was the material scant; the approach was still too narrow.

With the new century the approach gradually widened. New ideas were foreshadowed before that time; on the other hand many publications adhered to older methods even later. But the representative works showed a new orientation soon after 1900—no revolution, but a thorough revision of previous theories.

The general change of intellectual climate made itself felt. The new generation tired of the dissecting and atomizing tendencies of Positivism and its cold line-up of facts. They demanded a deeper understanding, an interpretation of the living whole, instead of mechanical addition. New suggestive slogans moved the minds, coined by neo-idealistic philosophers and the new depth psychology: dynamics, structure, "Gestalt," entity and totality, in philosophy, poetry, and art. The sensory impressions had been the corner stone of the old school of aesthetics, and color research was bound to reflect the change.

The impulse came simultaneously from many quarters; but the decisive attack was directed against the basic dogma of the sensualistic theory of art. Typical of the new attitude was the German aesthetician Th. A. Meyer. Most literary historians of the older school tacitly accepted the idea that richness of the sensory impression and strength of the poetic imagery were one and the same thing; Meyer and his followers drew this identity into doubt. Vision and poetry are not congruent, but different. Language does not offer a series of real sensations but a kind of shorthand symbol representing the perceptions; the words may be colored and accompanied by vague memories of sensory impressions but do not directly call them up. "In the poetic description of sensory objects we do not see the objects themselves as we do in a painting. We conceive the sensory object in a spiritualized kind of perception, to which we only link some associations from previous sense experiences." Any poetical description is therefore a transformation: the details can only be interpreted as parts of the new aesthetic whole which has been created, and within which all the means of expression are closely interrelated. The literary description "resembles" nature as a reflection in the water "resembles," and nevertheless shines like a strange, transfigured world.[19]

These views were deepened and developed by other aestheticians; the basic idea was concisely formulated by Cysarz: "Worte und Anschauungen decken sich niemals."[20] Language is "Anstoss" more than "Inhalt," suggestion more than illusion. The poetic image is not created by any single word but by the sentence, the rhythm, the sound, and indeed the whole work. Our aesthetic experience is an unending play of shades and values, changing from time to time and from individual to individual; the "sensation" in the narrow physiological sense is only a part of the aesthetic "Gestalt."

This school of thinking, which was focussed on the expression, received support from psychol-

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[19] Meyer (193), p. V, 157, 176 ff.

[20] See especially works by Barat (423), Brinkmann (178), Cohn (179), Cysarz (180), and Dessoir (181).

ogical studies focussed on the impression.[21] Most important were the results of the studies of color preference. Since the 1880's a large amount of time and work had been devoted to the investigation of the emotional impact of the colors. The test material had been dissected from all angles imaginable—character, age, sex, race, and surroundings;[22] but the result which crystallized more and more clearly was the dissolution of all mechanical law. Generally speaking, certain colors seem to call forth a richer quantity of associations than do others. But the emotions thus aroused prove to be so varified in quality that actually "we must be rather skeptical as to whether there is such a thing as color preference."[23] The color impression is not tied to certain extrinsic stimuli, but anchored in and conditioned by "all the other" factors, the whole psychological "Gestalt," in a constant interplay of the forces of the soul. The old talk of beautiful and ugly colors has only a relative sense as Allesch sums up (p. 157). No color is beautiful, no color is ugly. Each one of them can be everything if it enters the dynamics of the aesthetic process at the right moment and in the right place.

These conceptions signalled a total reevaluation of the function of the colors in literature; the clash of ideas is reflected in the important contribution to color research which from 1909 on was due to the German psychologist Karl Groos.[24] What Groos hoped to build was a real "psychology of literature," based on more sound and exact methods than the vague speculation of previous generations. He chose the colors as his starting point because in spite of their intimate connection with the life of the mind they may nevertheless to some extent be isolated; and he built his method on statistics in order to make the results comparable. In so doing he introduced nothing new; statistics had been used with discretion in color research before 1900. But new was the elaborate and systematic way in which he grouped and analyzed the colors and hues and tried to define their relative importance. Together with his students, Groos undertook to procure homogeneous color material for a series of the most important poets and periods. Others gradually supplemented his results according to similar methods; there are now detailed statistical "Groos-analyses" for Vergil and Horace (360), the Middle High German epic (862), Shakespeare (720), Edmund Spenser (754), B. de St.-Pierre and Chateaubriand (577), Goethe (918), Schiller (1051), Wagner (1080), and Richard Dehmel (882). In addition, numerous spot tests of other poets are included in the more extensive studies for the sake of comparison.

In extent of material and consistency of method no other contribution to literary color research can be compared to that of the Groos school, and his influence on later studies is manifest. But from the first moment he also met with sharp criticism, based on the general ideas mentioned above.[25] His critics contended that the discussed material is not really accessible by statistical methods. They maintained that the "items of sensation" which Groos grouped according to quality and added according to quantity, actually represent as many shades and variations as there are items, changing from author to author and from period to period according to individual sensitivity and literary tradition. Groos had tried to distinguish between such color words that are figurative and such that really "have a sensory content." To his critics this distinction lacked any justification; at the same time they criticized Groos' disregard of other sensory facts only because they were not linked to tangible "color vocables." The critics found in Groos exactly that identification of impression and expression and that mechanical standardization of the details against which the new schools were warning most energetically.

A number of these critical remarks reflected a general suspicion toward color research as such. There was a strong reaction in the new generation against the whole psychological approach

[21] The investigation of color in optics and physiology is of little importance in this connection; the discussion is now moving wholly on the psychological level. Surveys of modern color theory are made by Katz (24) and Parsons (34); a peculiar parallel to Geiger-Magnus' theories of evolution, only based on longer periods, is Ladd-Franklin's much contested hypothesis (27). Interesting in this connection is Raehlmann's attempt (167) to explain the differences in color preference in normal individuals by deep differences in the vision (refuted by Guttmann and Heine-Lenz, 156–157).

[22] Surveys, some of them with rich bibliography, by Allesch (1), Calinich (8, with history of the research), Dorcus (12), Guyau (15), and above all Hammond (16) and Chandler and Barnhart (9).

[23] Dorcus, p. 432.

[24] Groos has himself surveyed his color research (188). A somewhat apologetic discussion is to be found in two studies by his pupil W. Moog (194).

[25] See particularly Bosch (177), p. 129 ff. and 180 ff., and Stählin (199), *passim*.

to literature; in the handbooks of method of the extreme neo-idealists color plays a modest part, and little is said about its function as a bridge between the sensory and the poetic worlds.[26] But this is not the main stream. In the long run the discussion of Groos' theories proved to further the interest in color research and to cause a fruitful fermentation of ideas. In many respects the Groos school holds a similar position in the twentieth century as did Gladstone in the nineteenth: their methods and results were debatable, but the discussion made the issues clear and raised new problems.

In spite of his emphasis on statistics Groos himself was basically closer to the new school than to that of the 1880's. The mark of the young generation was a new openness toward reality: the colors were no more listed as examples of mechanical rule but seen as indicators of the dynamics of forces within a widely ramified mental structure. Groos himself made important hints in that direction. He never studied the colors in splendid isolation but saw them as a part of the entire mind, connected with all its forms of expression. Beside the color statistics he and his students carried through a series of analyses where the sensation was linked to other mental forces: the attitude toward music in Hoffmann, Tieck, and Schumann (984), the expression of emotions in Schiller (1052), the movements of the body as a poetic element in Kleist (1001) and C. F. Meyer (1022), the influence of religious ecstacy on the words of sensation in Suso and St. Teresa (1066). What Groos actually had in mind here was a synthesis of the expressions of the personality, not by summation, but in the modern sense. Others tried to carry on his work along the same lines.[27]

As the discussion deepened, the most scathing criticism against Groos was also reduced to more moderate proportions and his effort justified. In his reply to Th. A. Meyer, Groos admitted that poetic description may not necessarily call forth clear sensory images. But to many individuals such images are usually involved and therefore remain an important subject of analysis.[28] Groos' general aspirations did not come true; no "literary color psychology" developed from his statistics and probably never will. The realization of this fact may explain why Groos never tried to draw any final conclusions from the many investigations of detail which he had instigated. But he knew that his method was only one of many possible ways, and useful within its limits. He warned strongly against believing that figures and tabulations were able to solve all problems.[29] On the other hand he justly emphasized that statistics may reveal tendencies which do not meet the eye; and the strict accuracy which he tried to introduce and the subtly graded tables which he used for his analyses have exerted a sound influence. It is not least owing to the Groos school that the colors and sensation as a whole have been given more space in modern German research on style than in that of any other country.

The ideas suggested by Groos were developed more clearly and consistently by other psychological schools. In general, professional psychology remained a driving force within the field for decades but in a way different from that of the 1880's. Experimental and medical psychology is much less vociferous; depth psychology dominates, especially psychoanalysis. The strictly Freudian approach has not played any great part in the color research, and attempts of symbolic interpretation are rare.[30] The more marked is the general influence, the will to see the details and "trifles" in life and literature as traces of a growth, indicators of a personality with its own structure and its own relationship to the world. Quite strong also is the influence from Adler's theory of defective organs and compensation. The change of emphasis is conspicuous within medical color research: the psychiatrists have become modest. Still naïve "literary case histories" come into print, but much more numerous are the sober investigations penetrated by new ideas.[31] Significant is Mutschmann's bitterly contested hypothesis from

[26] See for instance Cysarz (180), Ermatinger (185), and Petsch (196).

[27] See for instance Prévost's study of M. de Guérin's feeling of his own body (520) and Griess' work on the description of music in Loti (555).

[28] Similar ideas with a more literary starting point were formulated by Elster (184, II, 279 ff.) and Walzel (200).

[29] See his autobiography (188), *Das anschauliche Vorstellen* (187), and his dissertation on Schiller (1051).

[30] See particularly Christoffel (10); for psychoanalytic interest in synaesthesia, see below. General bibliographies of psychoanalytic studies of literature are compiled by Baudouin (3) and Hoffman (19).

[31] For the former type see Gould on Hearn (677) and Vontin on Heine (967). Interesting analyses are those by Kahn on Goethe's eyes (923), by Weydt on Droste-Hülshoff (890), by Riese on Trakl (1079), and by Menz on traces of drug addiction in the color visions of Poe (708). Interesting general statements are made by Prinzhorn (36).

1919 about Milton's alleged albinism.[32] Mutschmann's main point was no longer to ascertain that the anomalous colors in Milton's poetry were due to pathological conditions in the retina but to demonstrate in Adler's terms how this anomaly became an isolating factor in Milton's psychological development, deeply influencing his whole mental system of balance.

The psychological school which, next to Groos and his students, applied its professional methods most consciously to literary color research was that of the typologists. To the psychoanalysts the individual "item of sensation" indicates the psychological history of the individual; to the typologists the color item also links the individual to larger groups. As early as around 1910 Bullough (7) and Bradford (6) made the colors the starting point of a subtle and interesting distinction of four types of personality which partly coincided with the results of the research in color preference. Müller-Freienfels turned the results of typological research against Th. A. Meyer: the literary imagery is as varified as are the psychological types of the writers, and will have to be investigated accordingly.[33] An important new element entered the discussion with Kretschmer's famous work on the body types which in many ways are linked to the types of sensation. All these trends were finally welded together by Jaensch and his collaborators.[34] In their theory of eidetic phenomena the vision was connected with other general typical trends in a most interesting way. In a long series of special investigations, opened by Jaensch's student Scholl, the details of color sensation were correspondingly linked to the body type: preponderance of form is characteristic of the schizothyme, preponderance of color characteristic of the cyclothyme ("integration") type of vision.[35]

These ideas were followed up in a series of literary analyses which tried out the methods in the material of living poetry and fiction. The program for such research was formulated by A. Brandl as early as in 1922 (777). In the Anglo-saxon field Bliesener (661) discussed the type of Coleridge's vision, especially what Jaensch called the "calotropic" trend in the imagery of the eidetics: the overemphasis of the beautiful and resplendent, intensive and saturated colors. In his analysis of Jack London's "Martin Eden" Groos pointed to the same trend, linked to typical eidetic symptoms both in the author himself and in the hero of the novel (686). The research has especially been focussed on Wordsworth; his poetry was discussed from this angle in the mentioned treatise by Brandl (777) and again in studies by Hensel (779) and Schumacher (784). The approach of these scholars is partly that of psychoanalysis: the lavish display of images compensates for a weak eyesight, but combined with that of the typologists: the sensations, when studied in their main trends, reveal the basic pattern of the constitution.

Several literary historians applied these ideas to Goethe (see below). Eva Langner (822) adapted the methods of Toulouse and Binet to the new views and analyzed the vision of form and color and other typical trends of soul and body in a great number of living German authors, with results corresponding to those of the Scholl school. L. Weiser-Aall discussed the eidetic trend in the Norwegian novelist Jonas Lie (1131). Above all, Kroh (819) applied the theories of Jaensch in a series of subtle analyses, explaining and interpreting basic traits in great German writers: the fragmentary character of Otto Ludwig's work, the overstrained imagery and acrobat-like irony in Tieck, Hoffmann's isolation toward life, and the semi-artistic traits in Scheffel. In spite of dubious details, from the point of view both of psychology and of literary history, all these attempts have yielded interesting results and raised important problems. For instance, several scholars have asked for an analysis of the normal development of color vision through life, a problem which is also of importance to literary research. Some experimental work has already been done; a thorough analysis of the material available in painting and poetry as compared with the results of typology would give more to go upon than we have now.[36]

All these investigations still have their starting point in professional psychology. But there is also a strictly literary line within the color research. This literary school maintains friendly and many-sided relations with psychology, but

[32] Bibliographies (which largely supplement each other) were compiled by Brown (694), Fischer (695), Saurat (701), and Wilmer (705).

[33] Müller-Freienfels, *Psychologie der Kunst* (33), I, 97 ff. The book has rich bibliographies pertaining to the research on types.

[34] See Jaensch's own surveys (21 and 22). A review of the literature in the field is given by Klüwer (26).

[35] See studies by Lüth (31), Lutz (32), Poppinga (35), Puhl (37), Ritter (38), Schmidt (39), and Scholl (40).

[36] See for instance Müller-Freienfels, *Aufgaben* (195). Good remarks in Gauger (360, p. 12 ff.); some experimental studies are listed by Chandler and Barnhart (9).

at the same time sticks to its independence and has acted as a continuous corrective to the hypotheses of the outsiders.

Depth psychology liberated the poetic world from the mechanical laws of science and showed the way to the open plains of the soul. But in their zest for discovery the innovators sometimes forgot that the world of literary creation maintains a certain autonomy even toward psychology and is not exhausted by its formulas. In their reaction against this new attempt of domination the literary historians sometimes went too far and proclaimed for the literary creation an artificial independence which severed its connection with life. But their principal thesis remains irrefutable: in the history of literature it is first and foremost through the literary media that the general psychological facts really come into existence. Experimental psychology has shown how color preference is determined not only by the constitution of the individual but quite as much by environment and social status. In literature one of the strongest of these environmental factors is the characteristics and traditions, means and methods of literature itself. Many psychological and medical studies of literature present a lot of correct and useful facts which nevertheless are dead—"tables of contents instead of books" (Croce). The material remains potential until it is shown in its clashes and settlements with the given forms of language, literature, style, and culture which have their own dynamics and their own balance of forces.[37]

In the first place this approach called for a new analysis of language, the basic fact in all literary creation—less as an example of general laws than as an element of a living and changing style. All through this research work runs the idea of the distance between sense impression and word expression which was so strongly stressed by the new school: language is no instrument of automatic color registration, but an independent and often unpredictable factor, influencing both impression and expression. Waetzoldt (65) and König (54) pointed out how vague and ambiguous is the color terminology in all languages. The number of existing color shades is so tremendous that the expression in words is bound to simplify, exaggerate, and cut away the finer distinctions. The terms are unstable and varying even in the same person and only a few colors can be clearly and unmistakably defined in words at all. The very denotation of the color shades from moment to moment is a creative activity where all the forces of the mind may come into play. König showed how strongly the affections influence the moulding of these language expressions, the urge for emotional coloring and the delight in contrast; Sperber and Spitzer (63–64) stressed the importance of perseveration, the emotional complexes and motifs. But language itself is a moulding force as well. The facilities for color expression differ widely from period to period and from language to language, both in quality and quantity, and the very structure of language, the existence or non-existence of notions, vocables, and syntactic constructions, limits the possibilities and points out the directions.

These ideas were elaborated and deepened by Weisgerber (67–71). His starting point was the sensations of smell with their abundance of shades and their baffling poverty of language equivalents. This poverty may partly be explained by the fact that the sensations of smell are vague and complicated in themselves and that their distinction is of relatively minor importance in everyday life. But there may also be a causative relation the other way around: language may have lacked categories, means of simplification, classification, and elaboration of the impressions, and this again may have influenced the sensation. Weisgerber followed up this idea with regard to the color words, supported by results of medical research. In some cases of amnesia the patients lose the wide (general) color names. Vision continues to function normally, but the perception is narrowed in a way which corresponds to the narrowing of the language ability; the patients have to content themselves with the most immediate associations.[38] This surprising fact, as well as corresponding phenomena in the children's language and adult language of several language groups, indicates that "the very interpretation of the sensation is a language function" and socially determined. "Color sense" is not given physiologically or psychologically, but to a great extent depends upon language training and language tradition. "We never find man as a natural creature, only as a language creature, grown into the world of ideas which belongs to his mother tongue."

[37] A good example of futile medical analysis is Chassé, *Styles et physiologie* (427).

[38] The material is published by Gelb and Goldstein (14) and Head (17).

This approach raises two series of problems: what conditioning forces have been given from time to time within the national and social language groups, and what are the forms and functions of this interplay of language and sensation? For years Weisgerber collected material for a book called *Aufbau der Sinnenwelt in unseren Sprachen* which never appeared; the title clearly circumscribes the task. The first desideratum is a real word history which not only follows the changing vocables within each period but weighs their power of expression and analyzes the whole heritage of associations and shades which they pass on to the individuals. Most of this work is still to be done as far as the color words are concerned. Isolated beginnings have been made like Müller-Boré's analysis of the Greek color words and their language tradition (295), Barat's survey of the romantic creation of new values in the French color vocabulary (423) together with Ware's preliminary study of Bernardin de St.-Pierre (578), and Massey's analysis of Shelley's and Keats' compound epithets (736). But the investigation will have to go far beyond the poetical and literary language and subject the whole word material to a comparative analysis. In most periods the elementary ground work for such studies is still lacking.

The width of the field was indicated in a brilliant sketch by Stewart (636). With English and American examples he demonstrated the part of science in moulding and widening the modern color vocabulary—first physics, then biology, and during the recent century chemistry. The founders of scientific optics who painfully brought down into words the differences between the various hues in the spectrum, the eighteenth century zoologists who undertook to describe the colors of hundreds of varieties of birds and fishes, the modern chemist who has to find some language equivalent to each of the countless hues of the dyeing industry are creative workers in language as much as the poets or novelists, and their innovations and systems of qualifying the colors have been gratefully taken over by the literary writers. In this century the lead is with the fashion industry. There is a gulf between the scant color vocables of Chaucer and even those of the Romanticists and the language of a present day dressmaker. The dress section in the catalog of a mail order house recently contained a color glossary of 336 shades; and the shades of nail polish or lipstick are relatively no less numerous. Stewart rightly stressed that, even if many such terms are necessarily ephemeral, the continuous common use of this highly specialized technical language is bound to influence and develop the sense of color and color distinction both in the broad public and in the literary writers and to add new special shades to the means of literary expression.[39]

But the color words are only one part of the color expression and not always the most important one. The process is many-sided, distant fields of language often are called into play and there are no clear lines of demarcation. When the historians of art try to make their professional analysis of hues they often have to resort to all the facilities of the literary style; the rendering of color impressions is connected with and conditioned by the entire structure of the language. These connections have been investigated in promising studies. Spitzer (465) discussed the characteristic French color expression *des yeux couleur de ciel*. He showed that this construction is not "only" a language device but depends upon psychological and historical conditions influenced partly by the language of administration and of advertising, partly by a realistic delight in lining up the things of the external world and calling forth the sensations without using the specific color words. He gave further examples from Italian and Spanish, and pointed to the task of writing the history of all these "adjectivizations" in connection with the differentiation of color impressions and the changes of fashion.

Spitzer particularly had in mind the origin of the formulas. But the neologisms, when created, are also bound to react strongly on the individual. These influences were further investigated along Spitzer's lines by Knauer (444–445). Because language is "more suggestive than precisely descriptive," convention or context often has to indicate the shade of meaning; and from period to period language offers very different possibilities of such expression, "now elegant, now clumsy, now coarse and tangible, now ethereal and abstract." Knauer surveyed the syntactical means of indicating color which have thus been used in French, from Latin times on. He grouped them according to ten main types and showed how they originated and developed, congealed or receded into the background, all of them within their proper layers of language, in a continuous interplay with the

[39] This problem is also touched upon by König (54, p. 191 ff.).

general currents of the time: Renaissance lyricism, the precious language of the Salons, and the economic and technical spirit of our times, all of them influencing and modifying the demands and the style of the individual writers.

There are also deeper and more difficult changes. Weisgerber (69) has pointed to the fact that the expression of color and brilliance in German shows a shift from one word class to another. In Old High German color was mostly expressed by adjective, brilliance both by adjective and verb, but still mostly by adjective. In Middle High German the expression of brilliance shifted toward the verb, and in the seventeenth century this shift was completed while color continually stuck to the adjective. According to Weisgerber this shift in the use of the word classes is hardly accidental but must spring from a change of psychological attitude: by nature the adjective expresses a more extrinsic relationship, a loosely attached quality, while the verb implies a deep and active connection between the color and its carrier. When the entire way of expression changes so completely, it can only be explained by a new relationship between man and the sensorial world. As yet we do not know the reasons of such changes; but we can hardly doubt their influence, particularly in poetry.

Many of these traits are rooted in one language and have only vague parallels in other groups. Others are quite general and connected with the very nature of language expression; and they serve as a continuous warning against over-estimating the "spontaneousness" of the poetic color expression. The typologists often have pointed to a "calotropic" delight in vivid colors which is predominant in the language of the eidetics; they have even tried to subject the entire language to the typology of Jaensch and Scholl.[40] It is tempting to confront such theories with that general tendency of exaggerating the memory of colors and stressing the most intensive component which several scholars have found to be inherent in language itself, regardless of the difference of types.[41] Other basic trends in the descriptive power of language also have to be considered, for instance the fact that language generally has less difficulty in expressing color than line because the color word conveys a full impression in itself while a line can only be provoked by an image or a circumlocution.[42] Ciacosa (376) has shown how Dante with amazing inventiveness makes the light effects in the Paradise increase by way of variation and contrast in a mounting crescendo till they are swallowed up by the dizzying radiance of eternity, but is unable to create a similar acceleration of the colors: "Mentre la luce è capace di differenze quantitative . . . i colori non si possono distinguere l'uno dall'altro che per qualità. Mentre due volte la stessa luce fanno un doppio splendore, due volte lo stesso colore fanno lo stesso colore." The predominance of light or color in poetry may be connected with such facts no less than with trends of physiological constitution or personal taste. Barat has made many striking remarks in this field. He thus points to the fact that language has a limited ability of distinguishing fine shades because the images need some interval in order to be called forth with full force and because they do not supplement, but replace, each other. The intellectual meaning of the vocables often hampers their descriptive power and thus influences the choice of words, and so on.[43]

The established sound associations in the language also play their part. Even in pure description many writers draw quite as much on language association as on real sensation; this phenomenon has been particularly emphasized in recent studies on the style of Tieck and of Victor Hugo. In the case of Theodor Fontane, Tau (896) showed how manipulation of mere word clichés may actually replace the sense experience. Several scholars have stressed the importance of rhyme in emphasizing or giving preponderance to certain color words in poetry. Pratt (630) showed how alliterating color words abound in Langland and how lavishly Chaucer and Scott use certain color vocables in their rhymes; Mann (453) found that the surprising predilection for "couleur perse" in Old French verse had a similar background. Once in a while the stress of rhyme-finding may even directly have called forth a new color term (Stewart, 636,—Chaucer's "azure").

It goes without saying that in such analyses the context and the aesthetical impression as a whole must constantly be taken into account. Monnier (506) offers a subtle example. When Flaubert in "Salammbô" three times describes

[40] Krechel (55).
[41] Ehrler (13) supported by Katz (24, p. 255).
[42] Donat (1067, p. 47).
[43] Barat (423, p. 175 ff.).

the Numids as "couverts de manteaux blancs," there is no question of a word cliché or an *epitheton ornans* but of three different descriptions because the colors surrounding these white cloaks are different each time; such conditions may often come into play. But frequently, at least, tradition is the decisive factor. The analysis is not complete until it is made clear how far the milieu of language and style has modified and moulded the literary expression.

A similar deepening of the problem can be followed in other fields of research. The scholars are less engrossed in curios; they better understand that the subject is an entity where no detail can be detached or isolated. Even the "history of civilization" now is less concerned with peculiar habits and customs and more with the colors as a part of the totality of life shaped by all its forces. Much of this material is mainly useful for the interpretation and annotation of literary texts, even if it may be of considerable interest in itself.[44] But there are also studies which adopt a wider view—not only dictionaries and compilations, but broad and vivid pictures of culture where the colors naturally take their place. The most outstanding example in recent years may be Huizinga's description of the fall colors of the Middle Ages (105).

Much remains to be done, however. We still have a fragmentary knowledge of the color world in which man has been living through the ages and the impressions which have thus worked on his senses, although it is beyond doubt that literature in all its forms has been deeply influenced by these everyday experiences. It may suffice to recall how strongly the color sense of our own generation must be influenced by the color photography, the color film, and the animated cartoon. An interesting beginning of an analysis is made by Hallar[45] in a small survey of the color words in modern Danish newspaper language. They show a surprising preponderance of white and black (not red, as is usually the case in poetry). This may be perhaps a reflection of certain trends in modern metropolitan life. The studies of word frequency both in everyday and literary language, which have recently been taken up, may also contribute to the understanding of this interplay of color surroundings, language, and literary style. A survey of the present stand of the research on word frequency is given by Haugen (1125).

The strongest interest in the field has been focussed on the history of religion and folklore, magic and symbolism. This is not surprising: all kinds of color superstition are fully alive even in our own times, as may be ascertained by a glance into the many current periodicals devoted to occultism.[46] Within the history of religion modern psychological methods have long been applied to the color study, and the field of folklore likewise has increasingly been penetrated by psychological points of view. In a programmatic book published in 1937 L. Weiser-Aall (142) stressed the need for having the sensorial elements of the folk traditions worked through with the methods of psychology, above all the eidetic phenomena. Much of this material can only serve as a background for literary interpretation.[47] But the field of symbolism, at least, is a frontier zone where it is often difficult to decide where the history of religion ends and the history of literature begins, and where cooperation is highly needed. One of the most important joint concerns is of course the ballad and the folk song. Both have been thoroughly analyzed in recent years with regard to the symbolic use of color.[48]

Group mind and traditional patterns are overwhelmingly strong, not only in "simple" tales and folk songs but in the whole field of symbolism. The details may vary considerably from time to time.[49] But within each period the interpretation often is unambiguous. Even in modern literature, the collective trend is pronounced and the writer still may struggle hard for anything like a personal expression. A number of studies have been devoted to the use of

[44] See for instance Lange's studies of heraldic colors in Chaucer (659). The extensive literature on colors in heraldry has been omitted here.

[45] In his book on J. P. Jacobsen (1108, p. 61–63).

[46] Among books, see for instance "treatises" by Bruce (84–85) and Zelinski (145).

[47] Color folklore is summed up with colossal bibliographical apparatus in *Handwörterbücher zur deutschen Volkskunde* (102), partly also by Mackenzie (116); literature on color magics is carried together by Thorndike (137). A general bibliography of symbolism is given by Dunbar (380) and Ewer (97).

[48] Generally: Gloth (258) and Brouwer (253). English: Mead (624); French: H. Müller (456); German: Daur (796), Hoeber (810), Massny (827), R. M. Meyer (829), Wentzel (866). Müller and Hoeber mostly discuss the set epithets, including the color words.

[49] Gummere (101) has shown with regard to black and white how strongly the church has worked as a stabilizing factor in color symbolism while the popular ideas were quite unstable, at least in Germanic tradition.

color symbols in individual authors (for instance Verhaeren, 584; several studies on Victor Hugo). But a real analysis is only possible if based on a thorough comparison with the conventions and literary fashions of the period, and they have not always received attention. Such conventions were especially comprehensive during the Renaissance. They have been analyzed on British soil by Allen (592) and Linthicum (620) and in numerous studies on color symbolism in Spain (400, 415, 416, 421) where at times the fashion was so rigid that the author had to give special notice if he intended to describe the colors of the real world. In such periods the analysis of personal shades of symbolism has to proceed with considerable caution. That is being done in the best studies, especially in Fleischer's book on Verlaine (586) where a broad description of the style of the period makes the symbolism of the author emanate with its real personal traits. But the interpretation of symbols may easily be exaggerated, and the codification of the "meaning" become too rigid. Flemming (799) rightly calls attention to the fact that the symbolic content of a color rarely is tangible like the meaning of a riddle or an allegory, at least in literary poetry, but rather may be compared to a vague resonance, an undertone, which gives the description a note of mysterious depth but defies definition. Here the analyst needs a light touch.

All the way these investigations move close to the domain of the "Stoffgeschichte." When, for instance, Hecker (808) analyzed the "Blue Flower" as a romantic symbol, it was obvious all through how the emotional impact of the color could not be isolated from its carrier. Now as before many of these investigations of subject matter are little but dead heaps of material, often amassed by young students for their degrees. As a whole, however, the horizon has widened. The strongest impression conveyed by these analyses is again the strength of literary convention: "sensation" with its complicated background of physiology and psychology is only one of the factors in the literary style.

This influence of the milieu is of course most pronounced in periods of strong conventionalism like the Middle Ages with their elaborate codes of literary description, only broken by the literary genius. The Dante research offers amazing examples, for instance the discussion whether Beatrice's emerald eyes should be ascribed to the color itself, to the detailed theological background of the diamond or to its tradition in folklore.[50] But also in other periods the interplay is much more intimate than is commonly realized.[51] A series of studies all since the 1870's thus has demonstrated how the description of the horse in earlier poetry largely follows an old color catalog, which dates as far back as Columella. Even Shakespeare did not find it to be below his dignity to toy with these venerable literary clichés.[52] The description of the human body adheres to a similar color pattern through great parts of literary history. Bødtker has shown (250) that the description of the color of the eyes in man follows a certain established tradition which again appears in Shakespeare; all the other details of description have their tradition likewise.[53]

These literary connections sometimes may appear as almost grotesque, especially with regard to the color of the human hair. In a long series of studies, partly moving into the realms of folklore and ethnology, it has been shown how writers of all times have distributed the colors of the hair among their persons according to a primeval popular psychological scheme which was systematized in the physiognomic handbooks of the Middle Ages and later appeared in the poets again and again, among others in Shakespeare.[54] This is the background of the bizarre and fantastic, but absorbing, work by Abraham (473) on Balzac's description of man. Investigation reveals that the crowd of human beings which throngs through *La Comédie Humaine* shows a distribution of the color of eyes and hair different from that which is found in real Frenchmen; and the distribution is not based on observation but is symbolic of the psychology of the persons. This peculiar fact may partly be explained by associations of language, what Abraham calls "mots-images": "l'œil vert" has a sound-connection with word groups like "pervers," "versatile" etc., and assimilates some of their content. But Balzac also partly

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[50] Austin (372) and Cioffarri (377).

[51] For instance, Porterfield (961) in his discussion of Hebbel's almost grotesque predilection for precious stones builds exclusively on psychological speculation, seemingly without any knowledge of the literature on diamond lore, like the books of Gimma (99) and Garrett (606).

[52] See studies by Bangert (422), Bertoni (396), Boehmer (43), Brown (717), Kitze (443), and Pfeiffer (841).

[53] Curry (596), Fleschenberg (289), Houdoy (259), Jóhannesson (1120), Michel (969), Schultz (132).

[54] See studies by Baum (77, with bibliography), Duhn (93), Jordan (442), Linthicum (723), and Neubert (457).

adhered to a traditional pattern: he borrowed from the popular color scheme in order to make intelligible spontaneous emotional complexes in himself which at bottom grew from his sexual constitution. Psychological character, mechanisms of language, and literary convention play inseparably together in the literary creation, and none of them can be detached without disturbing the balance.

The landscape is by far the most important subject of literary description. An immense amount of material has been amassed by the research of recent years, not least in doctoral dissertations. But orientation in the field is difficult. Specialized bibliographies do only exist for a few subjects,[55] and now as before the material is quite uneven from our point of view; the colors often receive little attention. To give an example, I have listed in the bibliography about a dozen studies of the description of the ocean in literature, which also make some remarks on color. But I know almost three times as many books on the subject where the colors are overlooked altogether.

Broadly speaking the research work has followed two lines, emphasizing either the emotion which craved for expression or the landscape which was the subject of description. The former approach has predominated, both in the analysis of individual writers and in the investigation of whole periods. But many of these studies would have yielded more solid results if the subject matter and its types had also been kept in mind. Groos and his school devoted much study to these carriers of color. Independently of him, Gubelmann (960) and especially Hallar worked out a detailed statistical method which makes the distribution to subject a main point of landscape study.[56] The method has to be applied with a continuous view to the history of style, however. Here Kammerer pointed out the way in his superior book of 1909 (815). In more recent years this field has produced Donat's outstanding analysis of the landscape in Tieck (1067) where every single color detail is attached to the corresponding detail in the landscape and its traditions and conventions of literary description.

[55] I mention as rare examples Baumgart's study of the descriptions of the forest (789), Zippel's of the winter motive (765), and Langlois' of flora and fauna (446–447).

[56] For the numerous color studies by Hallar—one of the most active contributors to the field in recent years—see the index of names. He has also made a general statement of his methods (189).

Only when this general background has been drawn clearly and comprehensively, can the analysis of emotion and expression in the landscape description of the individual writer have any hope of success. An investigation of the night and its symbolic value in the work of a poet may err badly if carried through without knowledge of the general night types—the "brown" southern night of the Renaissance which is still found in Nietzsche, the night of misty twilight which thrilled the Romanticists, the starlit, golden, "Classical" night which was the ideal of other schools, and so on.[57] In following the phases of Goethe's description of the moon, from the hazy pre-Romantic sphere of his Strasbourg years to the clear and luminous moon which makes the landscape stand out in plastic forms during his Italian voyage, the investigator likewise all the time has to weigh against each other the intentions of the individual and the heritage of his period.[58] Often such analysis may move into unexpected fields. Beitl (908) has demonstrated that Goethe's color vision is much richer when he describes faces than when he paints landscapes and that he even applies a different color scale. This is in itself an interesting fact. But in order to judge it correctly it is necessary to link this personal peculiarity to the interest of the period in physiognomics, which was again closely connected with its Classical ideal of humanity.

Especially interesting is the recent analysis of individual landscapes in literature and their special color scale. One of the best examples is Trüper's investigation of the North German plain as a literary motif.[59] The peculiar doubleness of the literary landscape is often brought out in these studies. Legras (492) has shown how Chateaubriand in his descriptions of his home district operates with two sets of landscapes: the ones he had really seen, with their actual light and colors, and the grey and misty land-

[57] See Cysarz (180); compare Hughes (768) and Nilsson (1183).

[58] See especially the study of Schulz (935) and also Petsch (930) and Weydt (890). How difficult it is to distinguish between observation and tradition in this field is demonstrated in a humorous way in the discussion by Yardley and others whether the color words in Shakespeare's sea descriptions may prove that he has really seen the ocean (731).

[59] 863. For the Alps see Engel (255) and Spindler (634), with literature. Compare studies by Jolly (499), Pinthus (479), Reinhold (888), and Weimar (715). Schriewer's book on K. Groth (949) also seems to draw into the picture the folk art of the district.

scape of Ossian, which perhaps was equally close to his heart but which in the main was literary. Pongs (1023) showed how C. F. Meyer's descriptions of Switzerland were built on actual experience, while his Italy was an elaborate idealization. Here, as well as in the purely philological analysis, the real task is to bring out the mass of associations linked to the various landscapes and thus follow the interplay of personal experience and tradition. Gradually this color analysis has also gone beyond fiction and poetry to the travel literature. The results are especially interesting because in the travel books the description can be compared exactly with the real landscape, and the literary remodeling with its general and personal characteristics can be distinguished from those traits which really originate from observations.[60]

A special problem is taken up in Krech's study of the landscape description in the plays of the Storm and Stress period (818). He analyzes the nature background in the drama all the way back to the Greeks, not only from a literary point of view, but in connection with the stage technique and its special demands, and with rich bibliography.[61] Another curious aspect is discussed in Linthicum's book on the colors of stage costumes (620).

The new approach has vitalized even the most sterile fields of color research. There is still much dead weight in the study of metaphors but also a breath of new ideas. Rickert (197) has developed a much discussed method for the analysis of "imagery," that is, the entire mental reproduction through words of "things seen, heard, touched, tasted and smelled." She sees the color images as part of the aesthetic structure of words, thought and tone patterns, rhythm, and visual devices; in the analysis she methodically applies statistics and graphic tables much along the lines of the Groos school but carefully avoids any standardization of the material. A similar dynamic view is adopted in Spurgeon's studies of Shakespeare's imagery.[62] Some scholars have attempted to make a cross section of the use of individual colors and the occurrence of synaesthesia in the metaphor in many languages (Swaen, 263; Stanford, 234).

In all these studies the impact of surroundings and tradition is analyzed and brought out in various ways. But the focus of the research has been on the great literary periods—the general waves of taste and style, sensitivity and expression which give each era its own indelible character as unmistakable as that of the individual.

The color investigators early began to interest themselves in these problems, above all those which are connected with Romanticism. Much of the most penetrating work from the point of view of method has been devoted to such problems; but the growth has been jerky and uneven. One important field, the development of aesthetic color theory, has been quite neglected. Some work has been done with regard to the Classical theory of description (for instance Howard, 260); Thorstenberg (1009) linked Lessing's views on color to his aesthetic ideals; Boillot (542) did the same for La Fontaine. More has been achieved with regard to romantic color speculation and its influence in literature and art, especially in Germany where both painters and poets have written theoretically on the subject. In more recent periods there are scattered important analyses like Sabatier's book on the brothers Goncourt (518) and Trudgian's study of Huysmans (539). But all through, much is left to be done.

Still more, this holds good with regard to the literary genres and fashions and the general ideals which they reflect. (This is not the only point where the history of the genres has been unduly neglected.) Scattered remarks of a more or less general character may be found in handbooks of aesthetics. But most of the material still has to be carried together from special investigations. Some useful information may be found there, however, for instance concerning the epic, the sonnet, Gongorism, the pastoral style (Browne, d'Urfé), and Ossian.[63] Some work has also been devoted to the typical traits of the various means of expression. Among the more solid studies is Roberts' investigation of Spanish Romantic epithet with a broad analysis of its sources (402).

The most dominating trait, however, is not the comparative analysis of detail, but ambitious attempts of synthesis which include not only the style of the literature in each period but also that of the other arts and the whole system of ideas

[60] See books by Hauser (610), Moebius (625), Moesch (709), Oertel (835), and Richter (843).

[61] Minor remarks on the subject may be found for instance in Quimby's and Taube's studies on G. Hauptmann (956–957).

[62] Critical remarks with regard to her method by Hornstein (191).

[63] See chapter II, and the bibliography. For Macpherson himself see especially Meyer (689), and for his influence on the color style Zyromski (547).

and emotions behind them. These attempts are typical of that broad and daring view which has been the mark of the humanities in recent decades. In the individual writers the colors are no longer regarded as symptoms of isolated trends of language or style, but as indicators of the very attitude toward life. This also holds good of the larger groups, and the problems often are similar. The "development" of an individual cannot be traced myopically from detail to detail, but has to be interpreted in the terms of general shifts, where quite heterogeneous psychological elements may come to the surface.[64] Similarly the general development of style has to be interpreted from the totality of the means of expression within each period. As Flemming has convincingly brought out in his study of German feeling for landscape (799) the growth of a national literature is less a sequel of "influences" than successive changes of layers in the social mind, traceable in all the various forms of intellectual and emotional attitudes. The elements are not primarily linked to each other but to the culture of the period as a whole. In this difficult field of depth analysis the history of art has shown the way.

The colors have always played a part in the history of the arts. Scholarly color research in the modern sense hardly developed until the second decade of this century, but then in great breadth.[65] A literary historian working with the colors in poetry may regard with envy the varied methods of color research developed by the art historians, both with regard to the technique of painting and the aesthetic theory. Some studies of this kind have an accessory value to literary research because of their analysis of the color terms in earlier writings on pictorial art (Heuck, 159). There is even in this field a close parallel to the present survey of research, H. Lützeler's bibliography and critical review of the color studies within the history of art (163), a treatise which is most recommendable also to the historian of literature.

If the two fields are studied more closely, however, it becomes obvious that a direct comparison and exchange of methods is difficult. The very studies which are most tantalizing to the historian of literature (for instance Bender, 146, or Hetzer, 158) make it clear how different is the use of color in poetry and in painting in spite of all first glance similarity. The colors of the painter are relatively unambiguous and stable. The hues may be defined with considerable exactitude and the composition often may be brought down to simple formulas. In this regard the painter colors have only little in common with the vague, suggestive, and elusive means of expression in language. The attempts which have been made to take over directly the methods of art history have therefore served literary research as badly as has the mechanical transfer of analogies from science. But in some fields a sober and realistic cooperation has been fruitful. And when the literary realities were not lost out of sight it has also proved possible gradually to approach the wider problems.

In the first place a surprising number of writers have themselves been active in drawing and painting (more rarely in sculpture), or have direct connection with the arts in some other way. This double activity raises interesting problems of joint importance to art and literature: the interplay of talents in the individual, the various aspects of the coloring within the different media, and the place of the painter-poets within the development of both fields.[66] General surveys have been rare as yet; the sketches by Binyon and Förster for English (593, 604), Dorbec for French (432–434), and Harnisch for German literature (805) are quite summary. Instead, a long series of studies has been devoted to the analysis of individual painter poets. Among the better are Martino's book on Fromentin (509), Beringer's and Born's on Scheffel (1048–1049), Roessler's on Stifter (1062), Koehler's on the brothers Goncourt (515), Lösch' and Wilmsen's on George Eliot and Thomas Hardy (667, 673), Tietz' on Rossetti (712), Federmann's on Füssli (900), Schaffner's on Gottfried Keller (999), Denk's on Maler Müller (1030), and finally the whole series of studies devoted to Goethe's drawings and Victor Hugo's paintings. Here there is an abundance of tempting tasks and unsolved problems, and much valuable material has not even been touched yet.[67] The study of psychological

[64] Well brought out in Weise's analysis of the synaesthesias of Balzac (477–478).

[65] The books mentioned in the bibliographical collections are mainly intended as examples. Bibliographies for larger areas are given by Mänz (164), Strauss (171), and Tikkanen (172).

[66] A bibliography for Germany is given by Bebermeyer (790–791).

[67] For instance, Calderón has himself written a tract on the colors in painting (Curtius, 404), which has never been used for the study of his own use of colors, as far as I know.

types may prove to be of importance; Kroh (819) has pointed out how the very vacillation between painting and poetry may originate from eidetic images which often seem to be equally fit for expression in words and in pictures. A useful instrument for further research would be an anthology of what the poets themselves have said about the colors. They have sometimes expressed their opinions at considerable length.[68]

Another aspect of the problem is the direct transfer of patterns and conventions from one art to another. Panzer (837–838) called attention to the interesting material of comparison which is to be found in illuminated manuscripts from the Middle Ages where poetic description and colored pictures often accompany each other. Atkinson (747) and above all Tuve (755) have shown how Spenser in his poetry adapts himself in detail to the pictorial conventions of contemporary artists, also in the selection and use of colors.

An important special problem presents itself in those quite numerous pieces of poetry and fiction where the writer describes a work of art. The relationship of Oscar Wilde to Whistler's impressionistic paintings has been the subject of instructive and many-sided discussion. An absorbing longitudinal section is given in Rosenfeld's book *Das deutsche Bildgedicht* (844) which pays much attention to color especially during Impressionism and sees everything in relation to the special technical demands of the "picture poem."

All these problems, especially those of the colors, focus in what the Germans call "die wechselseitige Erhellung der Künste," the attempt of finding a common psychological denominator of the arts. The problem is old; ambitious attempts were made as early as in the 1890's.[69] A review of the various theories up to recent years is given by Wais (236) and leaves the impression of unsolved difficulties and a lack of clear definitions. This especially holds good of the relations between the arts of words and of music. Serious efforts have been made to link them under joint headings,[70] but outside the special field of synaesthesia I cannot find that color research has much to learn from these speculations. The results rarely go beyond vague parallels, mostly built on numerical relations. The field which really has given results is the typology of style which was developed by German art historians, mostly after the First World War, and which managed to build the syntheses on a tangible material.

The attempts were made in various directions.[71] But they were all based on the conviction that each period of civilization has its own definite character distinct from others, and that the style of arts and literature is representative of this character, expressing the relation of man to the world: "Der Stil ist die Form der Weltanschauung" (Nohl). Above all it was Wölfflin (174–175) who coined the watchwords. The famous five pairs of antitheses by which he defined the Renaissance style as compared to that of the Baroque (preponderance of line and plane, closed form, "articulated multiplicity," and absolute clarity, with their counterparts) are not directly derived from the use of the colors. But in applying his theory Wölfflin repeatedly touched upon the colors because of their decisive importance to the question of the "picturesque" (173) and clearly outlined a Classicist and a Baroque color style.

His suggestions were applied to the study of literary history by Fritz Strich. He began near Wölfflin, in the German literary Baroque (859), and showed how the use of colors in the Baroque poets is typical of the whole character of the period. He then made his most important contribution by applying the same method to the contrasting styles of Classicism and Romanticism (860). Their basic difference, which Strich characterized by the antithesis "Vollendung—Unendlichkeit," is strikingly revealed in the use of color, similarly in painting and in poetry. Leaning on the rich investigation of detail by the previous generation of scholars, Strich was able to outline a "Romantic color type," which in all important features is representative of the "psychological structure" of the period.

These theories were vividly debated and contested; the discussion was not yet brought to a

[68] Guerlin has published an anthology of color judgments by painters (155) which also includes a few poets. Especially famous statements have been made by Goethe, Hofmannsthal (991), Ludwig (1015), Tieck (1077), Rèné Bazin (488), J. A. Symonds (758).

[69] See Chaix (219), Cœuroy (220), Combarieu (221), Lehel (228), Maury (230), and Walzel (237).

[70] Bibliography in Evans (436); compare Baldensperger (248) and Müller-Freienfels (231).

[71] A full survey of the problems, with rich bibliography, is made by Passarge (165); much material is also presented by Nohl (232) and Walzel (200). An early Homer study by Schuster (334, 1861) operated with line, contour, plastic form, and color in a way which much recalls the method of Wölfflin.

close before the war and cannot be summed up here. The range was wide, from uncritical acceptance and parodic vulgarization (Spengler, 135) to a rejection in principle of the very foundation of the type theories (Th. A. Meyer).[72] If the development is regarded as a whole, however, few contributions during the last generation have influenced the color research more deeply, less the details than the general approach. Admittedly the formulas need to be modified. The psychologist, Müller-Freienfels, criticized them in a most interesting way, sometimes approving Wölfflin-Strich's ideas, sometimes rejecting them, quite especially with regard to the color vision, and ended by adding two supplementing types. Obviously the scheme is still too rough.[73] Similarly the theories have been modified and the distinctions refined from the point of view of literary style. W. Schneider showed how the style changes, not only from period to period, but often from work to work within the same period, even within the same text page, and how the great antitheses must continuously be supplemented and modified by less comprehensive ones.[74] But the continuous modification and differentiation shows in itself how deeply the basic thoughts have penetrated into the research work.

The most lasting result of the whole controversy around the typology of style may be a clearer realization of the uniformity of the apperception within each literary period. Many recent studies on the general character of vision are of indirect interest to the color problem because they bring out this inherent unity; good examples are a number of studies on space and movement as expressions of the "structure of the visible world."[75] In a treatise on architectural fancies in medieval poetry Trier (264) surveyed the many descriptions of imaginary edifices from this period and maintained that they all have the same character. Apparently the pictures are made on a tremendous scale. But on closer inspection they prove to lack the grand format: they are only huge enlargements of miniatures, of the type of the altar-screens and the tiny, carved relic shrines; the vision proves to adhere to a typical pattern which binds the individual. Trier's explanation strongly recalls Weisgerber's theories: language itself still lacked facilities for expressing the large format, and the poetic description could not go beyond those limits.

Still more instructive is Langen's book on the picture of the visual world in the eighteenth century (821). The eye was strongly predominant among the senses during that period, as it has been in others; but people used their eyes in a peculiar way which was connected with their very conception of life. Langen calls it the "frame vision" (Rahmenschau): a rationalistic, didactic limitation of the field of vision to "the tiny area of acute apperception." The tendency is manifest in the mosaic-like lining-up of images in poetry, in the wide-spread interest in the literary "portrait," the "situation," and the "anecdote," in the book illustrations and the miniature-like engravings with their delicate, sharp-cut lines, and even in trends of material civilization like the patterns of the wall paper and the popularity of the peep show.

Whether this kind of vision is as typical as the author maintains remains to be proved. Deane (597) has shown that we may be quite as justified in speaking of a "prospect poetry" in the eighteenth century, with wide vistas which have no frame at all. But the idea itself is not less fruitful because it needs qualification. The parallels with Wölfflin are obvious and might certainly be worked out more clearly. A beginning in this direction was made by Strasser with regard to Gessner (906). That these general types of apperception are also of major importance to the use of color needs no elaboration.

How many lines of research have an intersecting point in the color study is clearly demonstrated in the field of synaesthesia.[76]

Beginnings of an investigation were made by John Locke, and more extensive speculation may be found in the works of J. Th. Woolhouse (died 1734). Real research did not get under way till after 1800, however, and was mostly limited to the physiological and medical aspects; scattered attempts of literary analysis (Lobeck 1846–282) were of minor importance. It was the Fechner school which by methodical investigation gradu-

[72] A survey of the discussion is given by Petersen (839); for a few reviews, see 860.

[73] Müller-Freienfels (33), I, 97 ff. For the relation to Jaensch, see Schumacher (784).

[74] W. Schneider (847), especially p. 189 ff.

[75] See for instance Hofstetter on Fargue (502), Todt on Tieck (1078), Hauttmann (806) and Kirchenbauer (816) on the Middle Ages. A recent bibliography on the whole problem of perspective in art is to be found in Bunim (149).

[76] Almost exhaustive bibliographies for the whole psychological field were published independently by Argelander (216) and Mahling (229). They have been compared, supplemented, and corrected by Wellek, *Zur Geschichte und Kritik der Synästhesie-Forschung* (245).

ally developed the various interpretations of the phenomenon (embryological, anatomical, physiological, and psychological) which now prevail. At the same time the first attempts were made of a real literary investigation (Petrich 1878–840).

During the first decade after 1900 the interest of the professional psychologists in synaesthesia tapered off somewhat. Instead, the study of its influence in literature began in earnest, inspired and egged on by that wide psychological ramification which is the characteristic of the phenomenon. Epoch was made by Ottokar Fischer (1907–1068); his work was followed by a long series of special studies and comprehensive surveys, mostly focussed on the period of Romanticism.[77] The approach varies considerably in these investigations; but as a whole they are penetrated by the views of the new depth psychology, especially psychoanalysis. In several studies (for instance 225, 233) the psychoanalysts criticized the physiological interpretation of synaesthesia. They maintained that the interplay of the senses is rooted in the associations and linked to deeply imbedded experiences of childhood, and that synaesthesia thus belongs to the individual in the full meaning of the word. From the other end Jaensch (226) with equal strength linked synaesthesia to his psychological types as a characteristic of those human beings who are especially close to the primitive stage: natives, children, artists, and poets.

An altogether new interpretation was attempted in the 1920's as the result of close cooperation between psychology and the history of literature and music. The most important names are Anschütz (215) and Wellek (238–247). These scholars tried to show that the synaesthetic phenomena have a more general character, are much more widespread, and go much farther back in history than was known before. We cannot only speak of a romantic synaesthesia but quite as much of a Greek, a Roman, and an Oriental variety. The new school also tried to anchor the phenomenon more intimately in language than had been done before. Wellek (244) pointed to the connections between synaesthesia and the language sounds, using the results of modern research on the timbre of the vowels;[78] and he also linked the phenomenon to the great historical types of style. According to Wellek, there are Baroque and Romantic types of synaesthesia which have certain traits together, while the Classical type represents the antithesis in accordance with Wölfflin's definitions. The "tectonic" synaesthesia of Renaissance and Classicism is plastic and formal and based on the hearing of light and color; the "atectonic" synaesthesia of Baroque and Romanticism is picturesque and musical and characterized by the vision of melody and timbre. These ideas, hypothetical as they may appear, have already made their influence felt in the literary analysis.[79]

All these efforts to build syntheses and gather the material under large headings spring from one of the most positive traits of modern literary history. But the trend also has its dangers. Most of the methods mentioned in the previous pages had their starting point in a sober analysis of limited, controllable material. But the innovators, and still more their followers, often displayed a tendency to leave the factual material behind and venture into the limitless fields of vague generalization. Striking examples of both types of research may be found in recent efforts to point out national color styles.

To define national characteristics is in itself a tantalizing task; a "national character" usually is as elusive as it is real. Most scholars have wisely resigned in the face of the problem; some of the best studies in the field (for instance Foerster's book on American landscape description, 605) have left the question almost untouched. Others have contented themselves with unpretentious sketches, built less on methodical analysis than on personal impression. These attempts, where learned and brilliant scholars have brought their long literary experience into formula, are often more instructive than any elaborate and ambitious definition. Good examples are Sweet's characterization of Celtic and Old English use of color (743) and in

[77] Among general surveys see especially Babbitt (217, strongly polemical), Erhardt-Siebold (256, 600), and Stanford (234). For Portuguese: Da Silva Correia (398). For Spanish: Lepiorz (401). For French: Binet (424), Cressot (428), Dillingham (511), Fernandet (482), Fleischer (586), Giraud (437), Pommier (483), Rauhut (460), Schwachenberg (587), Ségalen (464), Stroloke (466), Weise (469, 477, 478), Weiss (514), Woolley (471), and several studies on Victor Hugo. For English: Downey (599), Erhardt-Siebold (600 and 601), Freydorf (734), Gerstmann (746), Ullmann (640, 687, 706, 776). For German: Fischer (981 and 1068), Freitag (1059), Glöckner (982), Katz (984), Margis (985), Siebert (965), Silz (966), Steinert (1076), Stock (988), Wellek (1081). For Scandinavian: Berg (1144, 1171) and Mjöberg (1165). Scattered remarks of course may be found in many places. A bibliography of studies in literary synaesthesia is given by Wellek, *Zur Geschichte und Kritik* (245, p. 359 ff.).

[78] See as an example Beyer (218).

[79] See Weise's treatise on Balzac (477).

more recent times Legouis' contrast of modern English and French color styles corresponding to Taine's famous words about the antithesis of silverpoint and water-color (449). But such judgments are necessarily vague; and the efforts to support them by controllable research have mostly brought out how tricky is the material.

Least helpful actually have the psychological methods proved to be. The preference studies have demonstrated that no strong or stable national or racial difference exists with regard to the attitude toward color. Some psychologists have tried to turn this difficulty by attributing the differences to general psychological types which again in various ways are combined with alleged national characteristics; the results have not been encouraging. Especially, German scholars have indulged in fantastic hypotheses of this kind, making color vision and synaesthesia serve their political and racial propaganda.[80]

More substantial is the discussion of the factors of milieu. In a most interesting way Geikie (205) analyzed the differences between lowlands, plains, and mountains and the possible influence of these types of landscape as a subject of literary description; similarly Hellpach (208) studied the influence of the landscape colors. Such investigations could be supplemented in many ways by the studies of individual landscapes in literature mentioned above, and could be combined with an analysis of art. National color styles in painting have long been discussed in a sober, professional way.[81] The general conclusions still often may serve as a warning,[82] and even more sober studies like those of Müller-Freienfels (833) are not too exact. But there are also results on which it may prove possible to build, quite especially in the field of art geography. In an interesting study Gerstenberg (152) has tried to work out what he calls "zones of vision," from Northern Scandinavia to the Po Plains, based on the interplay of climate and types of style with pertinent remarks about the color; this is not mere construction. Gradually it may also prove possible to define more exactly some of the general trends of national culture which obviously have bearing upon the problem.[83]

It is of little avail to apply such theories to literature before the elementary philological ground work has been done, however. Weisgerber's ideas of the language as a factor conditioning the national color style have not by far penetrated into the practical research work as yet; and uncritical application may lead to absurd conclusions, as demonstrated for instance in Herms' attempt to prove the stronger "power of imagery" in German language as compared to English (809). But Weisgerber's own work shows that such aberrations are not inherent in the method; he has also in an interesting way used ethnological material in order to define the relationship of landscape, language, and color expression.[84] Above all, the investigations of Knauer (444–445) bode well; it is also worth while mentioning Esnault's attempt to point out special traits in the sensorial expressions in the dialect of one French province (435). Such work points toward a comparative analysis of all the various means of expression within the different languages. The best descriptions of national language styles (for instance Deutschbein's book, 598) are quite promising in this respect; unfortunately, color has received little attention in these studies as yet.

The subtle character of the problems and the difficulties in solving them by any kind of generalization are strikingly brought out in two studies by Huscher on the characteristics of English nature feeling (613–614). The mark of English sensation is to Huscher an impressionistic "Gemüthsweichheit": the British writer willingly yields to the landscape without that dynamic urge to impress himself upon the world which allegedly is the mark of the German poet. Huscher elaborates his definition in many fields, from literary genres and philosophy to painting and metrics, trying to derive their common features from the basic trends of English landscape, and his analysis often seems delicate and striking. But the fifteenth to seventeenth centuries have to be left out as different, and Burns, Byron, and Swinburne have to count as exceptions as well; here the "national" definition loses all sense. At the same time Huscher admits that similar traits may be found in other

[80] See for instance Baerwald (2), Lerch (450, chapter VIII), and of course Jaensch (226). The recent studies of the latter cannot be taken seriously.

[81] See for instance Plehn (166).

[82] See for instance the superficial generalizations in Hagen, *Deutsches Sehen* (803).

[83] See for instance Jan's attempt on French landscape feeling (441).

[84] See for instance his *Muttersprache* (70, p. 83) about the unbelievable abundance of shades for the desert color brown in the language of the Bedouins, and the note by Hess (51) about the similar richness of vocabulary with regard to the color of horses, which is also found in Iceland (Hamre, 1118 and Jónsson, 1121, compare also 59, 1122, 1124, and 1126).

artists and writers from coastal regions, for instance in the Normans, Maupassant and Flaubert, the Netherlander, Rembrandt, and the Ditmarsker, Liliencron; here the definition merges into a general typology of landscape. According to other scholars the "yielding to the impressions" has an eidetic background;[85] here the definition mingles with the general types of psychology. The basic definition itself is controversial to say the least; Deutschbein (598) declares the Germans to be predominantly impressionist and the British expressionist. Little is gained by such vague assertions.

This general lack of convincing results does not imply that the whole problem is not worth while investigating. But surely the work has often been taken up from the wrong end. "National characteristics" are not a clearly definable factor in the literary creation, still less a stable and changeless power, but at most a general tendency which is continuously being modified and can only be distinguished as a part of the whole interplay of historical forces. This also holds good with regard to color vision. The typical traits of a nation can only be brought out against the background of all the influences from the outside which have moulded its character; it is in the answers to the impact of foreign cultures that a national undercurrent may be pointed out with some degree of certainty. The lack of comparative color studies hardly allows for any conclusive results of this kind as yet.

In all these directions the research work of the recent generation has tried to point out the general forces which come into play in the use of color in literature. Only on this foundation it is possible to investigate successfully the use of color by the individual poets.

Here it is difficult to outline the methods in detail. The work can only be described from case to case as is partly going to be done in examples below. One general trait is common to the whole field, however: the cautious approach, the openness to a wide range of possible solutions, the understanding of the endless complexity of the phenomena, and simultaneously an urge to interpret them as a whole, in the individual writer no less than in the larger groups. In living up to such demands, which may be called fundamental to modern humanities, "idealistic" and more "positivistic" historians of literature work hand in hand in the interpretation, and from their somewhat different starting points they both experience that eternal miracle of literary research: that the analysis of tradition and surroundings only makes the personality and its unmistakable character stand out in a clearer light. This apparent contrast is strikingly demonstrated in a study like Vivier's analysis of Baudelaire's means of description (486). To an unbelievable extent they are borrowed from the milieu; taken all together they nevertheless are the personal property of the poet and reveal his style in every stroke of the brush. The doubleness is demonstrated from the other side in Belden's little survey of observation and imagination in Coleridge and Poe (660). The individual traits in the two writers are in many ways shown to be parallel within the framework of time and period. Nevertheless they have an almost opposite meaning because they belong to different personalities with different structures.[86]

If measured with such standards, the bulk of color studies still seem immature and experimental. There is much of heaped-up detail but rarely a precise description of the characteristics of a group or an individual. This is not too surprising if we take into regard how roughly the field is worked through as yet, how many of the leading theories have only been discussed in general outline, and how motley and complicated are the problems themselves. I could not mention one single study which might be said to reflect comprehensively the present methods, let alone to unite them into a whole. But even now it is possible to point out more limited investigations which indicate how fruitful the discipline may once become when all the tendencies have had their full play and have influenced and modified each other. Within the study of metaphor there is an analysis like Crétin's work on Corneille (496) with its subtle description of the shades of color and light as an expression of the spirit of Classicism, of an artist and of a man. In the field of type research there is a brief sketch like Zabeltitz' analysis of Stefan George (905), where sensorial impression and expression is made a battlefield not only for formulas of style but for deep conscious and subconscious forces in the poet himself. There is a series of valuable studies on Goethe and Victor Hugo to which we will have to return.

[85] Bliesener in her analysis of Coleridge (661).

[86] Compare Berendsohn's attempt to solve a problem of authorship by means of the color words (909). The result was disputable partly because the work in question was written in a rather pale classicist style.

Above all others I should like to mention Demorest's large book on the figurative and symbolic expression in Flaubert (503) which gives so much more than the title indicates. This scholar is able to combine an accurate description of color milieu, tradition, and historical background, a thorough interpretation of personal characteristics, a careful analysis of language and subject matter, and a sensible use of statistics with a delicate understanding of the aesthietic values, handling the varied material unerrongly within the framework of chronological devel pment. His work bodes good for the futurecontribution of the color studies to literary research.

II. MORE IMPORTANT RESULTS

In the previous chapter some general problems and methods of research were pointed out with examples from various literary periods. In the following the results are surveyed from a historical point of view. There can only be question of a superficial orientation focussed on the main periods in the leading countries. Individual writers are discussed at some length only when they keep a dominant position in color history and have been investigated correspondingly. For all details I refer to the bibliography.

Classical Antiquity has played a great part in the development of color research. In the old literatures themselves, however, the colors are not too conspicuous, especially not in the great periods. The philologists have sifted the material carefully from the points of view of etymology and semasiology and analyzed the shades of meaning which were once discussed so passionately. There has been a veritable avalanche of treatises on the metaphor, but here as elsewhere the colors have usually been included in the catalog of subjects only by chance; a somewhat more important part is played by the light.[87] The material pertaining to the history of religion is nicely brought together (see the bibliography, section C). But the analysis of the history of style is more uneven. Much of the energy has of course been absorbed by the Gladstone controversy.

A good general survey of the development in Greek literature from the simple color scale of the epics to the refined play of hues in Euripides was given early by Fairclough (288), and an exhaustive analysis of the color vocables by Kober (290–291). While the latter presents mostly a philological compilation of the material, she also has good comparative remarks and interesting excursuses on the technical production of color. The problems of style in all the early poetry were discussed by Müller-Boré (295) with an altogether modern approach. The book takes its starting point in the literary demands which at each time called for the color words and dictated the use of them. Against this background the author follows how the terms held their ground, receded into oblivion, or changed their shade of meaning, sometimes in connection with, sometimes independently of, the general development within the prose style.

Müller-Boré called for a usable analysis of the color problem in Greek art. Here the results were long coming, and the material is in itself uneven. Interesting comparative studies were due to H. Schultz (302) and F. Winter (305). Like Müller-Boré they linked the relative poverty of color in the epics to a general convention of style: the epic seems to prefer brilliance to color, and not only with the Greeks. They showed how the development within the epic period, both in poetry and art, runs from a simple, but subtle, color scale to calcified conventionalism. They pointed to the general influence of Greek landscape which lacks the meadows, the humid atmosphere, and the effects of haze and twilight and is dominated by line and form and the colorless blaze of the sun.

More thorough comparative studies may be expected when the magnificent archaeological finds of recent years are utilized for literary research. An important beginning was made by Wallace (335) who used as a background for her discussion of the colors in Homer both the landscape colors, the dye-stuff production, and other practical applications of color in the world in which the authors of the epics lived. Wallace began her studies in order to prove Gladstone's theories but ended up by delivering the final counterproof: "The physiological color sense of the Greeks perhaps was higher developed than ours." But she also showed absorbingly how great is the power of conservatism in matters of style, and how strongly tradition dominates the use of color words regardless of the physiological sensation. Words and things were quickly tied to each other as used by Homer, and the vocables soon became as unsuitable for realistic description of nature as were the simple pigments in

[87] A bibliography of the research work in this field 1885–1932 is given by Assfahl (359).

primitive art. The history of Greek color style is largely the history of the liberation from this venerable heritage.

A desideratum within Greek color research—and in the study of other old literatures as well—is a critical discussion of the material in the terms of the modern typology of style, particularly the origin and meaning of "Classical" color tradition. The attempts so far do not always inspire confidence.[88] An important initiative for the whole field is due to Gunnar Rudberg. In a series of studies devoted to the Classical "theoria" (298–300, 307, 308, 332, 338) he has tried to describe the vision as an elementary force in the life of Old Greece, from direct sensation all through the scale to philosophy and religion, closely connected with Greek landscape, one of the most promising attempts to see the colors as an integrated part of a national culture.

In the field of *Roman* literature much work has also been done in the border regions, philology and history of religion. A number of studies have been devoted to the description of landscape (particularly Allen, 340, and Friedlaender, 345). Within the history of style interest has naturally been focussed on the overpowering Greek tradition. Earlier scholars often were led to interpret straight color clichés in Roman poets as a result of direct sense stimulus. Modern analysts have learned to peal off with subtle methods the crust of tradition, the archaisms and petrified formulas taken over from the great models, and thus bring out what is really fresh and living. One of the most original colorists in Roman literature is Ovid, and Mayer's analysis (356) has great interest even from the point of view of method. Gauger's study of Horace and Vergil (360) with his combination of Groos-statistics and philology also deserves mentioning.

The *Middle Ages* in many respects offers a more motley material than does Classical antiquity, and the research work is rich and varied even if the point of view of the "Kulturgeschichte" is somewhat predominating.

The Gladstone controversy called attention to the colors in all primitive periods of literature including the early Middle Ages. The old epics became especially popular with the earlier school of literary historians who strongly felt their kinship to philology. Both in the Germanic and the Romance fields there is now a long series of studies on color in the archaic poetry, most of them linguistic, but some also adapting a more literary point of view. The English field probably has been cultivated most thoroughly, but the other countries are not neglected either. The material is to a large extent dug out and arranged for inspection. New progress can only be expected from a fresh approach.

The most extensive color research naturally has been focussed on the High Middle Ages where the ground is less tricky than in the primitive period and the material overwhelmingly rich with highly complicated problems. The delight in colors is a predominant trait of the time and has called forth a long series of investigations. In the fields of customs, heraldry, folklore, magics, liturgy, and all forms of material civilization compends and compilations now are available which handily present the material.[89] But the relationship of these surroundings to literature raises peculiar problems. The pomp of color which was so beloved in the High Middle Ages may seem gay and motley to us. Actually it is in a peculiar way systematized and made to serve remote abstractions, partly by an extensive use of allegory and symbolism, partly by a use of set topics and combinations which remind one of epic formulas but nevertheless have a character of their own, drawing narrow limits both with regard to subject and description. A considerable part of the color study in medieval literature necessarily has been concentrated on these formulas of expression; this especially holds good with regard to the description of landscape. The use of color is often quite limited. But within these limits the poets follow a rigid pattern with regard to season, flora, and color scheme.[90] The same holds good for the other fields of description which are often common ground to the historians of civilization and of literature: robes and raiments (Bertelt, 792), banquets (Bodensohn, 793), female beauty (above, p. 178), etc., all with their elaborate catalogs of details to be included and patterns to be followed.

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[88] For instance Riemschneider-Hoerner's recent effort to demonstrate that Homer belongs to the "Baroque" color type (331).

[89] See especially Gloth (258), Seelmann (851), Uhland (265), Wackernagel (267), Weinhold (140), *Verfasserlexikon* (797), and Mayer-Rietsch's edition of Hermann von Salzburg (974), as well as several parts of chapter I above.

[90] See especially Böheim (251), Bollmann (425), Ganzenmüller (257), McLaughlin (262), Schneider (846), Stockmayer (856), and Stoecklin (857).

The analysis of this rich and at the same time poor system has made clear how different from ours was the very conception of the sensorial world in the Middle Ages as reflected in literary creation.[91] The colors in the medieval poets have something peculiarly vague, unstable, and elusive, as if they were continuously oscillating between reality and fancy. The words change their shade of meaning according to need and situation, or even merge, almost like symbolic signs. Old French "vair" sometimes is used about horses, sometimes about the brilliance of shiny steel; "bloi" lapses into "bleu," "pale" sometimes is associated to white, sometimes to dark hues (the rhyme formula "pale et nerci"). To medieval man these words had a background and resonance of experience and imagination which they have now lost. "This is no more our sensation than the sculptures on the cathedrals have our faces" (Wilmotte).

These phenomena have double interest because they coincide in time with a magnificent painting and sculpture which to a great extent bowed to similar principles of style. But the problems of color in medieval art have not yet been brought into real contact with the literary analysis. A program of research for the German field and an authoritative survey of what has been done so far are due to Fr. von der Leyen (824); there is also a general review of the problems by Bebermeyer (791). An important beginning by Panzer (837–838) is pointed out above. Instructive is the discussion of the general forms of apperception—the concept of picture (Hauttmann, 806) and space (Kirchenbauer, 816) and the "ideal distance" which characterizes them.[92] As yet nobody has tried to work through all these problems as a whole, however, and little has been done even of preliminary studies.

Still less has been achieved in connecting the color style with ideology and general attitudes. Secret links tie the fields together, and even the fragmentary investigations so far have pointed to interesting traits, not only with regard to allegory and symbolism. It may suffice to mention Schneider's idea that the graceful, luminary, and glittery in medieval landscapes actually was felt as an unconscious defense against the demoniac forces of nature which could only be mastered poetically by such stylization (846). Similar connections will certainly be found in many fields when the material is interpreted as part of the larger picture.

The dissolution of this firmly built color culture, the shift toward an Oriental magnificence and a less rigid symbolism (in German literature particularly through Walther and Wolfram), and the gradual transition to realism and genre poetry have been studied repeatedly, not least because the development more or less clearly foreshadows the Renaissance. Chaucer is of special interest in this connection as a figure of transition, and his position has been strongly emphasized by the discussion of his colors.[93] As had to be expected, the interest has particularly been focussed on *Dante;* more than any other personality of the time he looks both toward the past and toward the future. He is by far the medieval poet who has been most thoroughly analyzed with regard to the use of colors and even from the standpoint of otology (Bilancioni, 373); only Gottfried von Strassburg and Wolfram von Eschenbach can be mentioned in comparison.

The bulk of the color studies in Dante are naturally concerned with the part of the colors in that allegorism and symbolism which is one of the dominant traits of the *Commedia.* Many of these details give thrilling and instructive evidence of the deeply medieval character of the work with its mixture of magnificent visions and pedantry. Colluri (378) has pointed out how the different colors of the three faces of Lucifer have their background in a traditional pattern which can be traced back to the three horses in the Apocalypse; Austin (371) has shown that the color green suddenly disappears when the poet reaches the Heavenly Paradise because green is one of the colors of hope and in Heaven all desires are fulfilled.

Symbolism apart, it is mostly the peculiar and complicated relations between light and shadow which have been investigated, in a long series of affectionate and subtle interpretations especially by Dante's own fellow countrymen (main work: Magistretti, 384). These studies strikingly demonstrate how well everything in the *Commedia* is thought out and how conscious and assured is the planning. A number of scholars have also discussed what Dante may have known, understood, and appreciated of the art of his time, and the possible links or parallels between

[91] Well described by Mann (453) and Wilmotte (470).

[92] Compare Trier's book (above, p. 183).

[93] See Pratt (630) and especially Turmann (639).

his own method of description and contemporary painting.[94]

A survey of the whole field and the wider historical problems was made by L. O. Kuhns (381). In a sweeping analysis he placed the descriptions in the *Commedia* against their background of tradition and conventional patterns, and again demonstrated how deeply Dante was rooted in his era. But against that background he also brought out those features of his literary art which point beyond the Middle Ages, above all a richness of observation both in quality and quantity which is not medieval and directly heralds the Renaissance. This sensitiveness is obvious even in the more obligatory descriptions. Dante's picture of the Earthly Paradise certainly borrows its elements from the inventory of tradition. But the material is used in a personal way; and this also holds good of the colors. Dante introduces the apple tree in his poem as a stereotype symbol, directly taken over from tradition. But he does not neglect to put down the color of the blossom with a delicate sense of the hues. He describes winter and spring with the conventional color clichés but adds a note on the color shade in the newly blown foliage, probably the first poet in literary history to do so.

This acuteness of the color vision is general in Dante, whether he observes the flowers or "the blood from a fresh stab wound." He displays the same sense of shades in the light effects, from "torch light seen through alabaster" to "the pearl on a white brow." And these details are not just a varnish applied to the surface; they reflect his very attitude toward the world. In a remarkable study Leo (382) has shown how generally dominating is the sense of vision in Dante, both when he adds detail to detail in the way of the mosaic-makers of his time and when he creates a picture by one masterly stroke. But this visionary power in the optic sense was only the reflection of an inner vision, that "spiritual eye" and "inner light" which the scholastics spoke of; and the physical power gradually bowed to his spiritual vision and obeyed its laws. Before the *Commedia* Dante was either a philosopher or a poet, both apart. In *Commedia* all is welded together into the universal expression of his times.[95]

If Dante may be called colorful, it is only as compared to other medieval poets, however. The first great break-through of color in literature both with regard to quality and quantity is due to the *Renaissance*. Not only did the new school of poets use the colors more than did their medieval colleagues; they cultivated them with an unrestrained delight which is radically different. The research work has been correspondingly intensive. But the epoch is motley and complex and difficult to characterize. Beneath the obvious common traits there are great differences; the development varies from country to country; the lines often run criss-cross. This tangle is not yet straightened out as far as the colors are concerned. There are few periods where the lack of comparative points of view is more strongly felt.

To my knowledge the Romance literatures have been least thoroughly investigated. For the *Italian* Renaissance little has been done although the subject should seem to be attractive. The most important work has been devoted to Petrarchism with its rigid conventions of motif and description, particularly in the English imitators (Groos, 720; Hillier, 612). *Spain*, which in so many ways holds an exceptional position, has not much research to boast of either. For *France* there is more. Earlier works are quite meager (Voigt, 468); and some of the earlier writers are themselves surprisingly poor with regard to colors, as demonstrated in Lote's treatise on Rabelais (568). But when we reach the times of Ronsard the material is abundant, and several good analyses have been made. Cornelia (573) still limited her investigation to the Classical background. But Levengood (451) described exhaustively Ronsard's relation to all the traditions, those from Classical antiquity and Italian Renaissance as well as those from Old French, the latter actually emerging as the stronger. Levengood also analyzed thoroughly the vocabulary of the other important poets of the school. Great methodical interest has his investigation of the shades of meaning in the poetic translations which played such a great part in the period.[96] Leader of the school, in the use of colors as in all other respects, was Ronsard himself: "more copious hues of color are not to be found in any French verse poet before Romanticism." For the following period with its gradually fading colorism little has been done. Neither could I mention any comparative study of the use of color in contemporary art.

[94] More important surveys by Brinckmann (374) and especially Cossio (379).

[95] Compare here Ewer's interesting study of the "spiritual senses" in the mystics (97).

[96] Similar studies in Pratt (630, p. 7).

Much richer both in regard to material and analysis is the *English* field. The sudden bloom of British culture from Shakespeare to Milton has also attracted the color students. Some earlier works on the description of landscape and the metaphor were not too important.[97] Much more substantial was Allen's study of the symbolism of the period (592); but the main contribution is Turmann's philological analysis (639), supplemented from a more literary point of view by Pratt (630), Hillier (612), and Linthicum (620). Turmann carefully surveyed the color vocabulary in English literature beginning with the fourteenth century and Chaucer, especially the creation of color words during the Renaissance, and distinguished two conflicting color styles which are the moving powers in the creation. The heroic-pathetic tradition was prepared for in the Middle Ages, broke through with Chaucer, and carried a definite victory with Marlowe and Spenser—a bizarre transfiguration and glorification of the human form by resplendent and intensive color formulas which almost detached the words from their original meaning. Besides, there was a naturalistic style, particularly in the description of landscape, which gradually gained ground but did not conquer the heroic tradition until Milton.

Within this general framework several individual portraits have been drawn. Good representatives of the heroic tradition are Philip Sidney (Brie, 745) and above all Spenser. His elaborate use of the colors has been discussed thoroughly (by Davis, 748, Elton, 749, and particularly Sohr, 754); so has that of Marlowe (Hillier, 612). On the other side, or rather as a "man in the middle," stands *Shakespeare*. He cannot be reckoned among the great color poets. His relation to the arts has been well analyzed, with the result that he rather has to be called "ear-minded."[98] But his transitional position and his poetic genius make him interesting even in this regard.

The first thorough statistical analysis was made by Groos and Netto (720); about the same time Haberl (721) tried to follow Shakespeare's color development by similar methods, showing a slow shift back and forth between the various fields of sensation. Barth (716) published the first penetrating analysis of Shakespeare's color epithets and proved that they represented something new as compared to those of his predecessors. The exhaustive analyses then followed in the 1930's in the pertaining chapters of Turmann's book and especially in two surveys of the imagery, probably the most elaborate investigation which has so far been devoted to the subject by any writer. In her great book Spurgeon discussed thoroughly Shakespeare's whole sensorial life as the soil from which his images grew; she included a broad chapter on the colors but especially emphasized the delight in change and contrast which actually thrilled him more than color proper.[99] From the other side Clemen (718) discussed the poet's conscious use of the images all through his literary creation. Historically Shakespeare reflects in his own development the whole movement away from the heroic color style to naturalism. In his youth he adhered to the former and was always able to use it with increasing mastery in making the elements tone harmoniously with each other. But it was the latter which gradually grew in strength.

This development was carried to an end by Milton. The early statistical study by Squires (704) showed how the landscape with its naturalistic demands gradually moved into focus in Milton's poetry; his color vocabulary is simple but is used in a magnificent way. Pratt and finally Heide (611) discussed the problem in detail from all sides, tracing the connections with tradition and contemporary style.

In the countries surveyed so far, the research has mainly operated with the terminology of the "Renaissance" in the more traditional sense. Relatively less has been done in order to distinguish that trend of literary *Baroque* which made itself increasingly felt within the movement—even in Shakespeare—and is particularly obvious in the selection and use of colors. A good general sketch is V. Vedel's little article on the color pomp of the period, in life, art, and poetry (266). There are a few studies on Gongorism;[100] much research has recently been devoted to the various English schools of the seventeenth century (for instance Crashaw, 666) but the color results are not too impressive. The most important work has been done in Germany where the interest in the Baroque was one of the strongest trends of literary research during the

[97] Moorman (627) and Carpenter (595).

[98] See Fairchild (719), Thorp (728), and especially Woermann (730).

[99] 727, compare 725 and 726.

[100] Especially Gates (411), Salembien (412), and Thomas (413).

inter-war years.[101] In numerous studies, some of them even dating quite far back, a huge material has been amassed about the peculiar color style and imagery of the period. Especially worth mentioning are Abmeier's book on the description of spring (785), Waldberg's on the gallant lyrical poets Hofmannswaldau and Lohenstein (865), and Fricke's and Krapp's comprehensive analyses of Gryphius and Harsdoerffer (950, 955).

The general background was splendidly outlined by Sperber (852): the dissolute postwar atmosphere with courts and princes as the only fixed points in life, with artifical erudition, turgid bombast, and cheap pomp compensating for the feeling of uncertainty, and with a luxuriant colorism, a perverse exaggeration and glittering variation in language, imagery, and style serving as an outlet for the stored emotions. Strich (859) applied his typology to this delight in colors and brought the characteristics into relief by contrasting them with the Classical ideal. The Baroque style with its lack of contour and definite form, its dissonances and overdecoration, its restlessness and vagueness, haunted by the ever-present idea of death which makes life "a beautiful illusion," represents the complete antithesis to Classicism and is not limited to literature. Hoerner (811) and Müller (832) applied Strich's categories to the color style in the art of the period and found there the same lack of objectivity and factual approach and the same vague merger of the individual traits, all springing from the common ground.

These brewing contrasts were a ferment and a power of dissolution all through the Baroque till finally toward the end of the seventeenth century the development changed into its own antithesis. If *Classicism and Enlightenment* are the modern literary periods most poor in color, it is partly owing to a direct reaction against the oversaturation of the Baroque. But at bottom the new taste springs from a different attitude toward life, which also demanded a different color style—sound and secure, simple and ungarnished, intellectually clear. The colors do not disappear. But they are pushed into the background in favor of the contour, the line, and the plastic light which create order, bring out the tangible form, and give everything its proper place.

Color research is not overwhelmingly rich in the field of Classicism. Often it has to judge *e silentio;* this does not make the work less interesting, nor does it demand less of sensitive interpretation. It is natural that France holds the strongest position. Among the general surveys the most important is Crump's analysis of nature feeling during the reign of Louis XIV (429); he also broadly discussed contemporary art. In contrast to previous scholars Crump showed how the rich colors of the Renaissance held their ground for a considerable time after 1600; he then followed in detail the transition from vivid colorism to the dominance of form and line around 1660. The change is analyzed in equal breadth by MacCann (452) and the results are followed up in several special studies. Mention has already been made of Crétin's book on Corneille (496). In a thoroughly interesting way Crétin demonstrates how color is only accessory to the play of light in Corneille's writings, and how this attitude reflects his spirit, active and close to life. Light is necessary for action; the colors are slack, voluptuous, and contemplative, sterile.

Adam (579) followed the same line through the writings of Saint-Simon; they show a similar preponderance of light, form, and touch impressions, and little display of colors. But the most extensive analysis in the field, and the one which grasps most of the complicated literary problems involved, is Boillot's book on La Fontaine's sensorial world (542), one of the best modern studies of literary colorism. The severely controlled use of the colors reflects not only La Fontaine's personal taste but that of a whole literary epoch, governed by the ideals of selection, harmony, simplicity, "exactitude," "justesse," "manque de différentiation," the basic classical principles.

There are also several solid investigations in the German field. In an interesting study Epting (953) demonstrated how in Hagedorn's poetry the use of color dwindles as Classicistic ideals push the Baroque conceptions aside; Thorstenberg's book on Lessing and the colors (1009) shows another aspect of the same problem. An excellent sketch of the obligatory pattern of landscape description is made by Ausfeld (787); Langen's book on the "frame vision" (821) is referred to above. Outside the great countries there is a splendid analysis of the colors of a classicist author in Margit Abenius' book on the Swedish poet Kellgren (1162).

[101] A survey of recent studies, without mentioning the colors, is made by Lunding (826). Important general remarks are to be found in Viëtor (864).

Many of these studies are good and important; but it cannot be denied that the material often is meager. The field where color research has been able to show its full possibilities is the second great period of delight in colors, *Pre-Romanticism* and *Romanticism*. The strength of the research work is due not only to the abundance of material but also to the contrasts and tensions and the whole motley character of the period. Romanticism is a movement of reaction against Enlightenment and Classicism; and color is one of its most important symbols. But many of the forces and ideas against which the Romanticists battled most violently were strong within themselves, and they were unable to deny or conceal it. This makes the development varied, dialectic, and antithetic, and makes the research watchful and resourceful.

Germany was the country where the wave broke the dams in earnest; the research also has been many-sided and enthralling there. The first attempts of a color analysis of the Romanticists were made as early as the late 1870's (Petrich, 840) and were followed by a number of studies during the decades preceding 1900. In full breadth the problem was tackled by Steinert (1076). His book discussed thoroughly all more important Romantic authors and was of considerable importance to the further development of the discipline. A broad stream of investigations followed, discussing partly Romanticism itself, partly its forerunners in the eighteenth century.[102] The typologists eagerly scrutinized the style of the period, particularly the Strich school. So did others, not least the psychologists;[103] the connections with theory of art, philosophy, and "Weltanschauung" were repeatedly emphasized. Hardly any other period of literary history has been the subject of such penetrating color studies. There are few of the ideas mentioned in the first chapter of this article which have not been tried out in the field of German Pre-Romanticism and Romanticism.

The first signs of revolution within the landscape description were surveyed by Batt (788), Schönfeld (848), and Schütze (849), and above all in Kammerer's epochal work (815). The curious landscape poetry of Brockes was analyzed thoroughly by Janssen (873) and Pfund (874). There are a few studies on the first representatives of the Storm and Stress, especially Heinse with his interesting relation to the arts; some attention has also been devoted to other senses than vision (Unger: Hamann, 954). The leading man of the new school, even in regard to the colors, naturally was Tieck. He is broadly analyzed in Steinert's book; besides, he was discussed more or less thoroughly by Miessner (1074) and Haussmann (1071), and finally all through again by Donat (1067). The relation of his color theory to that of Jacob Böhme, Runge, and Wackenroder was investigated,[104] as well as his sense of space (Todt, 1078); the psychologist Kroh tried to approach him along the ways of the eidetic school (819).

Tieck is the most important man in the group. But most of his followers indulged in the same Romantic colorism and have been analyzed from that point of view: Jean Paul (Bayer, 1037, Böhme, 975, and especially Henz, 1038), Novalis (Gloege, 1036), Görres (Wagner, 907), Hoffmann (many studies), Matthisson (Krebs, 1016), and several writers of minor order. Finally, Rehder (842) broadly described the philosophy of landscape of the Romanticists and the deeper motivation of their colorism—how light and color became to them much more than mere optical or aesthetic facts, the symbol of their "relation to God and the world."

But beneath this main stream of the movement there is also all the time a counter-current which runs from the sources of Classicism and keeps the inheritance alive, not in the obsolete form, but reborn by the new forces. Leading within this group are of course the avowed Classicists, like Schiller with his steadily decreasing use of color, Hölderlin who shows a similar parsimony, and on the other hand Platen with his stately neo-Classicistic color scale. But the undercurrent is equally evident in more purely Romantic types, at least as an oscillation (Denk: Maler Müller, 1031). Gradually the turn made itself felt in all the Romanticists: they tired, their ideas changed, in a sobering and cooling-off which signalled the Biedermeier. Tieck's development led him away from the color intoxication of his youth. In a splendid study (892) Nadler has shown a similar growth in Eichendorff, from young-Romantic colorism to late-

[102] A handy summary of the color results is given by Stefansky (854).

[103] See for instance Jenisch' analysis of the period, built on the contrast "subjective-objective" (814—a variation of the Strich antithesis), with a number of remarks on the colors.

[104] Grundy (1070), Koldewey (1072), Krebs (1073), and Roch (1075).

Romantic love of the light; and there were venerable models to whom to return.

This interplay of revolution and continuity within the Romantic movement is strikingly demonstrated, in colorism as in most other fields, by *Goethe*.

Goethe's relation to the colors early thrilled the historians of literature: he was himself so absorbed by the problem. To him the colors were not only a subject of science to which through many years he devoted independent and serious research. They were connected with the basic principles of his aesthetic thinking, both with regard to literature and to art; and his own attitude shows a peculiar and complicated play of disparate forces. Till the second decade of this century the research work was quite sporadic, however, with an exception made for Goethe's studies in the physical color theory, the results of which were early questioned. In 1895 Volbehr tried his hand at an analysis of Goethe's relations to the arts (938), and a decade later Kutscher published his conscientious discussion of the historical background of the young Goethe's landscape description (925). But none of these studies made any attempt of psycho-physical interpretation as visualized by the new school of literary history.

The beginnings of a deeper view may be found in a study by Franck (918) who applied the statistical method of the Groos school. His results were not too important in detail; but he established beyond doubt that Goethe's own colors were not rich as might have been expected but relatively poor. Carlowitz (912) continued along the same line, gave further proof of the poverty in Goethe's colors, and showed how instead he displayed a tendency to contrasting light and darkness, surprising when one remembers how important were the colors in his thinking.[105] But these suggestions were not followed up in earnest until the typological school began its comparative studies of literature and art.

The new approach was apparent in a little book by Hillmann (922–1916) which in many ways anticipated later results. According to Hillmann, Goethe had a highly developed "color sense" in the elementary, physiological meaning of the word. But he lacked understanding of the colors as an element of picturesque description; when he described, he usually brought out the form, not the colors. The idea which was here touched upon was followed up in full breadth one decade later in two superb studies by Beitl and Bruns (908 and 911—1929 and 1930). Neither of them mentioned Wölfflin or Strich; but obviously it was their ideas which now started things moving.

Goethe never became an independent painter or draftsman, Beitl maintained, and never had any spontaneous *aesthetic* color vision, at least with regard to the landscape. The Italian voyage with its vivid use of colors certainly meant a break through for the color sense, but only for the scientific color vision, the exact observation. The pictures which Goethe himself produced during the voyage were contour drawings with color added afterwards. When he used the colors in his poetry, they were accessory, not primary as a poetic element, and they gradually receded into the background till Goethe's interest in color theory actually superseded the colors themselves. The fact that Goethe had a strongly developed vision of light fits well into this picture. But he theorized much less about the light: it was the senses which were weak in himself to which he devoted most speculation!

Along the same line Bruns maintained that Goethe certainly was visual far beyond what is normal but that his vision almost exclusively was focussed on the plastic shape. What counted to him was form, line, contour, shadow, and light. The color was kept in the background and mostly used in order to "plastify" the form and emphasize or bring out the line. Somehow Goethe seemed to lack confidence in the colors: they were subjective to him, and veiled or adulterated the clear form. According to Bruns that predominance of non-spectral colors which was demonstrated by Carlowitz actually proves that the shades of light were most important to Goethe's eye. In accordance with Beitl, Bruns pointed out how "Römische Elegien," where there is so much talk of the colors, themselves are far from being colorful.

According to this conception Goethe is to soul and body a "constitutional Classic." Contrarily, Fechter (916) tried to give a more historical explanation. Goethe actually was sensitive to colors to a rare degree. If this ability is not reflected in his poetry, the main explanation is to be found in his surroundings during the formative years of his life: the abstract trend of the period, its aesthetic ideal of "selecting, not

[105] Gausewitz (919) later maintained that contrary to general opinion "Goethe's acoustic registry considerably outnumbered the optic."

painting," its reluctance to allow one poetic ability to dominate as against the others, and, last but not least, Goethe's artistic education and his impressions of art from early youth on. But beneath this crust his color sense remained live and strong, according to Fechter; it was only subdued and controlled. Therefore we often feel in his interested attitude toward the colors of other poets or artists a stored, unused energy which is thus released.

There is certainly an element of truth in Fechter's ideas. But they immediately raise the question why, after all, Goethe followed *this* trend of his times and not others? Fechter's views apparently are supported by one of Beitl's theories which is mentioned above: while Goethe lacked aesthetic color vision when picturing landscapes, he seems to have had a much more vivid aesthetic color sensation in his physiognomic descriptions where he was supported by a definite literary fashion. But this phenomenon is so closely linked to his deep-rooted "Classical" interest in man that it is extremely difficult to decide whether the constitutional ability or the influence of the surroundings gives the real explanation. There are other facts which point in a similar direction. According to Trojan (937), it is not only Goethe's literary use of colors which shows a tendency toward a "Classical" contrast of black and white: there are parallel trends in his symbolic use and even in his color theory. A certain basic trend, a "constitutional type," thus apparently will have to be reckoned with.

One hardly needs to speak of more than a trend, however; and it is modified in multiple ways. This is nowhere more apparent than in Goethe's attitude toward art. Numerous studies from recent years have discussed his own attempts as an artist and his relationship to contemporary painting.[106] They make clear that he does not only display an obvious trend toward Classicism but equally clear tendencies in other directions. Goethe certainly turned away from the Storm and Stress-painters in disgust. But at the same time he was the faithful helper of several of the younger Romantic painters. In his own drawings there is a strong Classical trend, especially after the Italian voyage. But he never adhered to any pure Classicism. His drawings rarely worked with the sharp line. Very often he used the wash technique, which is not severely Classical. On the whole, the more Goethe is studied the more richly facetted he seems to be, shifting, reflective, and inconsistent. The great Classic ended by loving van Eyck.

But a basic tendency certainly runs through all his changeableness. It is revealed unambiguously in his attitude toward the great representatives of that art which most clearly ran contrary to his own artistic feeling. In an interesting study Korff (924) analyzed Goethe's relationship to the Gothic, which for a while he worshipped, and showed that his appreciation was not based on real understanding. The Gothic which he could love was not the real Gothic but one which he interpreted away and unconsciously adapted to a Classical ideal, as another expression of harmony, only peculiar and strange. For this reason the Gothic could later disappear from his horizon and the Greeks quietly take its place.

A similar attitude, more directly connected with the color vision, has been pointed out by Münz in Goethe's relationship to Rembrandt (927). To the theorists of art before Goethe, Rembrandt was certainly a great painter but only when he had been "cleaned of the slags" according to Classical taste and reduced to a modest realistic master of intimate scenes, clever in the clair-obscure. Goethe began in the same school, admiring Rembrandt as a kind of transition figure from Baroque to Classicism till with the influence of Herder a much stronger enthusiasm broke through, never quite to die down again. But a more thorough analysis discloses that those deeper characteristics of Rembrandt which are most contrary to Goethe's own ideals—the violent inner tensions which are expressed in the covert struggle between line-, light-, and color-composition in his paintings—those Goethe neither loved nor understood. Even in his later period he tended to reduce Rembrandt to a good-natured, realistic painter of idylls, "a greater Ostade," acquiescing with Classical resignation within his narrow circle of life. It does not seem to have occurred to him that Rembrandt "forces the whole world into this frame," without rounding it off in the Classical manner. Goethe's own drawings after Rembrandt-motifs show this cleavage with almost drastic clarity. The same contrast is apparent in Goethe's color theory where he has no place for brown, Rembrandt's principal color, because it is only a "chaos," a "pollution." For the same reason he was unable to grasp Rembrandt's interplay of clarity and

[106] See the bibliography no. 913–915, 929, and 931.

obscurity where the light is penetrated by an eternal and never satisfied disquiet—the light that to Goethe was the very symbol of form and order. Even here he applied his own yardstick.

The most comprehensive explanation of all these trends has doubtlessly been offered by the Jaensch school. As early as 1919 Sarauw (934) published a broad analysis of Goethe's visual images which—obviously without knowledge of Jaensch's theories and terminology—is the most extensive demonstration in existence of Goethe's eidetic trend. It is striking how closely these traits correspond to the results of the typological studies of art. Further details pointing in the same direction were gathered by Groos (921); but above all it is Kroh (819) who has used the material for real conclusions. Goethe had an extraordinary ability of seeing clearly, keeping the images before his inner eye, and reproducing them voluntarily; many of his works are written in a kind of visual trance of this type. But above all it seems to have been the form which was clear to him in these visions, without that calotropic pomp of color which is common to most eidetics. He has himself strikingly explained the working of his mind in his description of the origin of his Morphology of the Plants —how he saw the "protoplant" unfold before his inner eye in ever purer and more definite forms without any effort on his part. In such constitutional trends we may expect to find the deepest explanation of Goethe's color vision and of the whole "Classical" attitude toward life from which it springs—no studied theory, but the subconscious pattern of his mind. Wide perspectives here open to the research.

No attempt has yet been made to work all these details and theories into one connected picture; and mutual checking and supplementing is highly needed. According to Franck and Bruns, Goethe used the colors more freely in his old age than in earlier periods of life; Beitl maintains the opposite view. Münz stressed the difference between Rembrandt and Goethe; Hamann (804) gathered the old age styles of both under the label "Impressionism." The eidetic interpretation does not lack ambiguity either. Goethe's peculiar and well known ability of "seeing the world through the eyes of another artist" was used by Beitl as a proof of his lack of independent vision, but was interpreted by Fechter as an outlet for his pent-up visual energy. Goethe's attitude toward the "Classical" ideals has been interpreted in diametrically different ways (a doubleness which often occurs); to Bruns and Beitl Classicism was his obvious form of life, to Korff it was a day dream never to be realized. We are still far from any exhaustive interpretation of Goethe's use of the colors. But the complexity and many-sidedness of the problem have been demonstrated perhaps more clearly in his writings than in those of any other author.

In all this research work German scholars gradually defined a Romantic type of color style as distinct from other styles; and to some extent it is generally valid. But there are also other Romantic trends, which are most strikingly developed in the literatures outside Germany. Several years back Fr. Brie (252) defined what he called the Romantic "exotism of the senses": a hectic hunting for extraordinary sense experiences, far from the idyllic, mysterious, heartfelt, and gentle which is mostly implied in the current definitions of Romanticism. In Germany Heine alone represents this trend, according to Brie; in Western Europe the tendency is more general. Deutschbein (254) followed up these ideas in a distinction between Romantic and what he called" Romanesque." While the former has a trend toward synthesis, the Romanesque style is one of contrast, characterized by a delight in the exotic, grotesque, abnormal, and bizarre, the sudden spasms, and shrill dissonances. These trends may be encountered in all the great countries; according to Deutschbein, Tieck, for instance, belongs to the Romanesque type. But it is in the Western literatures that they are most predominant and show most facets.

The contrasts are especially obvious in *English* Romanticism. As Fehr has emphasized, eighteenth century literature in England is unusually complicated with regard to the colors (603). A number of lines have nevertheless been drawn through the pre-Romantic period, above all in Myra Reynolds' comprehensive analysis of the feeling for nature (631), but also in other studies, great and small.[107] They have been supplemented by good work on individual writers, above all Thomson; both Anwander (761) and Morel (764) have followed the interesting clash of Classical and pre-Romantic colorism in his poetry. Much work has also been devoted to the colors of Romanticism proper. Good remarks on nature description are due to Opp (628). But the most important general survey

[107] Deane (597), Gothein (607), Haas (608), Hussey (615), and Manwaring (621).

still is that by Pratt (630), who analyzed the color style of the individual Romantic poets quite extensively and also traced their connections with pre-Romanticism. A figure of transition is Coleridge, and his colorism has been well investigated. We have earlier mentioned Belden's study (660); solid work was also done by Bradley (662), Möller (664), and especially Hosch (663).

With Keats and Shelley the Romantic colors then broke through unmistakably; and the research work has followed the process carefully. Above all Shelley has been the subject of color studies with an interesting approach. Massey (736) presented comparative material from a wide field of literature; Huscher (735) analyzed the poet's sensation with subtle distinction of the various fields according to their relative importance. The problems here present many parallels to contemporary German Romanticism. As in Germany, there is even in Great Britain a persistent undercurrent of Classical tradition, manifest both in Shelley and Keats. In a similar way as in Germany "pure" Romanticism is also early modified by a trend of Realism, especially in W. Scott who is less color-intoxicated than his contemporaries and more interested in the line (Weimar, 715).

But the well-known formulas are also modified by other trends which are especially obvious in Wordsworth. His sensorial life has been thoroughly discussed from various points of view; Heard (778) also broadly analyzed the acoustic elements. The main work is Hensel's psychological discussion (779). Hensel maintained that originally Wordsworth's sensation was thoroughly Romantic and (with Jaensch's terminology) reflected a youthful integration. But other constitutional trends gradually entered the picture, won the upper hand, and dissolved the integration, exsiccating both his sap of life and his delight in colors; Wordsworth's great poetry originated from the struggle of these forces. The approach here is that of the German typological school, but there are traits in the British material which do not fit into the German pattern. In Schumacher's discussion of Hensel's results (784) they are gathered under a formula which does not correspond to that of Wölfflin-Strich but rather to Deutschbein's antithesis of Romantic and Romanesque.

In Lippert's book on the use of color in Byron (655) these features are brought out with a clarity and consistency which could hardly be paralleled with regard to any German Romantic. While Oeftering (782–1901) could still content himself with pointing out the Classical background of Byron's descriptive technique, the whole analysis now unforcedly fitted into Deutschbein's formula. The "Romanesque" in Byron is a picturesque style which violently strikes the eye, as contrary to the soulful Romantic urge toward the "endless." While in the Romantics the delicate hues blurred the contours, the Romanesque school loved the sharp outlines and the saturated, crass colors, not vague and fluid, but moving violently and suddenly, zigzagwise like the lightning, with "a brightness exaggerated into a blinding glare, mostly pitted against absolute opacity." This garish, motley, and superficial opulence is one of the characteristics of Byron's style, both in his selection of the colors and in his rough, indiscriminate use of them, in the light explosions and lightning effects and in the impressionistic flicker. The difference is also revealed in the composition. Where the Romantics tried to give their pictures depth and linear perspective according to Wölfflin-Strich's definition, the Romanesque style worked with the contrast of horizontal and vertical. This whole discussion clearly demonstrates how helpful are typological ideas in opening the eyes to new traits of reality and also how the formulas incessantly have to be modified and adapted to the facts which they themselves bring to the light.

Within the Romantic movement *France* holds a position in the middle. "La persistance classique" was stronger there than anywhere else. The wave rose later, lasted for a shorter period, and did not move the depths as much. This notwithstanding, the change was considerable; and the new color style which was brought on by the pre-Romantics has been analyzed more thoroughly in France than in any other country. The transformation of the means of expression from 1740 to 1789 was extensively discussed by Gohin (438). Landscape feeling and description were evaluated in detail both by Mornet (455) and Haas (439); the former also included a huge material gathered from the history of civilization. Finally there is a whole literature discussing the individual innovators in literary colorism. Rousseau was carefully analyzed by Mornet and also by Buchner (575). Bernardin de St.-Pierre, that peculiar figure of transition, was also investigated by Mornet. His language was discussed in detail in the mentioned study

by Ware (578), and Heege (577) traced his relation to Chateaubriand.

With regard to the Romantic movement proper the results are more meager. A masterly panorama of the whole Romantic revolution of style was given by Barat (423); in his broad main chapter he sketched both the Romantic theory of description with its background of pseudo-Classical ideas, and the literary color practice. Subtle observations are also to be found in Charlier (426). But the more thorough investigation has largely been limited to a few poets and writers: Fromentin (Martino, 509), Lamartine (several small treatises), and Gautier (Weiss, 514, and especially Dillingham, 511). The poet who gives the period interest beyond the ordinary is *Victor Hugo*.

Few writers in world literature have been as overwhelmingly dominated by their visual impressions. His color visions early aroused curiosity—there are beginnings of an analysis in Sainte-Beuve; but real investigation was not attempted till the 1890's. Degenhardt's catalog of metaphors (526) is of minor interest; more enthralling is the work of Mabilleau (532–533). His analysis was carried through with refined understanding of stylistic values and in great breadth; he even to some extent used Hugo's numerous drawings, and supplemented his results by a comparative study of the other senses. Mabilleau thus was able to point out the main line of development within Hugo's literary colorism: the increasing preponderance of the light-shadow contrast, which gradually made the colors proper take on a symbolic character and made the images sever their connection with the real world till in his old age they became a kind of unsubstantial dream. But in explaining these phenomena Mabilleau still fully belonged to the school of Taine and Hennequin. The reasons of Hugo's peculiar color style could only be physiological, an anomaly of the color perception which allowed the light to pass through but increasingly filtered the colors off. There is evidence in his poetry of a morbid synaesthetic play with the colors but never of precise observation.

This theory was presented in an attractive form without the gross exaggerations which often marred the writings of other literary historians of the physiological school. Admittedly there are trends in Hugo's poetry which seem to support the interpretation; as late as 1934 it was restated in modified form by Matt (534). But in most quarters the theory met with immediate criticism because of its over-simplification and its obvious neglect of the factors of literature and style. A violent protest based on purely physiological considerations was formulated by Meetkerke (535–1901). But the decisive criticism came from a deeper aesthetic penetration of the material. In 1904–1905 Huguet published his two books on Hugo's metaphor (530) with their rich analysis of the sensorial world, and they clearly showed the turn of the tide.

Huguet's first result was a refutation of Mabilleau's principal claim: Hugo's physiological color sensations were both rich in quantity and highly varied with regard to the hues. But Huguet's main purpose was to show that, if these impressions were not fully reflected in Hugo's poetry, the discrepancy was due, not to any physiological peculiarity, but to an aesthetic selection connected with Hugo's whole character *as a poet*. In analyzing the factors which here come into play (summarized in the color-volume, p. 105–106) Huguet masterly demonstrated the place of the colors in the interrelation of sensorial impressions and poetic creation. Hugo's color vision certainly was keen and comprehensive. But as a poet he was more thrilled by other trends of reality: by movement, form, and contour, often in geometrical simplification, sharp and cleancut like a checker board, and above all by the interplay of resplendent light and darkness, not because his eye could not perceive anything else, but because this material corresponded to his deep-rooted delight in the antithesis and the Romanesque "éclat rayonnant." The colors which he admitted into his verse were intensified and the fine shades cut away because simplification and magnification were basic trends in his poetry. He modified and changed them in multiple other ways according to the general emotional atmosphere, the symbolic content, the need for personification, and all the other factors that are active in the creation of a homogeneous literary work. And these trends increased in strength in the ageing Hugo, not because his eye changed in the physiological sense, but because his characteristics as a poet deepened more and more with years.

In this book the physiological theory thus was finally disproved by purely aesthetic and stylistic arguments. What was still lacking in Huguet's analysis was a psychological interpretation of Hugo's literary character as a part of his whole mental growth. Beginnings in this direction may be found in Stölten (538). His book was

only intended as a chronological supplement to Huguet; actually he outlined a deeper explanation which has later been confirmed, linking the literary use of color to the general development of Hugo's ideas. The reinterpretation of Huguet's material then was made in great breadth by Joussain (531) in his brilliant analysis of the picturesque in Hugo's aesthetics and poetry.

In his judgment of Mabilleau's theories Joussain wholly agreed with Huguet; but he drew the line of development with much more detail and with much more emphasis on chronology. Hugo began in unclear color experiments. With *Les Orientales* he then turned to a firm and clear, almost Classical color style, close to reality and based on rich sensation although mastered and controlled by the demands of composition. But soon his mystic, Romantic trend began to work under the surface. Observation dissolved under the irresistible urge for expression. More and more Hugo approached a visionary, hallucinatory style where design, colors, and details disappeared behind the violent contrast of black and white. From the time of the exile this style broke through in pure form, expressing Hugo's limitless feeling of space and his conviction of unity in the universe. The picturesque was devoured by gigantic visions. The color hues were extinguished; the note became dark, poor, and monotonous, exception made for a few hypnotically suggestive flaming colors—"une vision grossissante, déformatrice et toute subjective." Not till Hugo's last poems do we meet the third, clarified form of expression which Joussain calls his "poetic" style. It is now altogether spiritualized and lacks both design and color, quieting down and dying away like an echo.

This establishment of clear periods in Hugo's color development is in itself highly interesting. But still more important is the way in which Joussain makes the growth of Hugo's sensorial characteristics outline the development of his whole psycho-physical personality. Hugo's tremendous sensitiveness was the decisive fact of his life. He was abnormally open to the world, subjected to his senses, helplessly under the sway of his impressions. In a kind of self-defense he instinctively tried to penetrate and subdue the sensorial world in order to find and bring out that hidden meaning, that all-embracing sympathy which, behind the seeming confusion, he felt was bound to be there. In this struggle for mastery he gradually liberated himself from the dominance of the sensorial world; the forces which built up the picturesque in his poetry, in their turn, broke it down. This inner development explains why Hugo's use of color shows such a surprising independence: during Romanticism he was a Classicist, during Naturalism a Romantic. The colors are not only a part of his literary form, but symbolize his changing attitude toward life.

These ideas were carried on in Robertson's book on Hugo's epithet (536). She only discussed Hugo's works before the exile, and in the details she did not go far beyond Huguet. But her description of the inner development confirmed the main lines of Joussain's picture; she also used the drawings as body of evidence. The psychoanalysts further deepened the interpretation. Baudouin (524) maintained that the trend toward antithesis in Hugo's color vision could be explained neither by physiological nor literary considerations, but reflected a basic ambivalence which had its roots in the very foundations of his personality and moulded his mind.

From various directions attempts have thus been made to explain and interpret Hugo's color world. But common to these attempts is that they all, more or less reluctantly, take their starting point in the finished literary work, cast into its form of words and sounds. Here the research of the late 1920's and the 1930's has applied new tools along the lines indicated especially by Weisgerber. In a penetrating review of Joussain's book Franz (528) pointed out that what was still lacking in the study of Victor Hugo was a philological interpretation of his style. The poet paints with language- and word-images; and these words and sounds are—not least to Hugo—loaded with associations which are bound to influence and even distort the "vision." The "picturesque" in Hugo's poetry often is not primary at all, neither physiologically nor stylistically, but derived from mere associations of language; the details thus are useless as sources of an "inner development" of the vision. The interpretation outlined by Joussain is built on a failing ground. The changes in the use of color words do not necessarily reflect deep shifts in Hugo's "painter's eye," but may depend on the fact that "with increasing years language association with remote trains of thought occurred more and more easily in him and with less and less of inhibitions."

When Franz put forward his thoughts as a criticism of Joussain, he was somewhat unfair.

In the general part of his book Joussain discussed the modifying function of language quite extensively. But doubtlessly these factors have not received as much attention as they really deserve. How far this approach may take us is still difficult to say; but the attempts are promising. Schenk (537) has followed Hugo's "verbomania" in detail and showed how his mechanical "delirium of associations" modified the creation and even sometimes changed its direction. Graef (529) analyzed the effective conclusions in Hugo's lines, stanzas, and poems and showed how often a concrete detail, especially a light effect, creates the strong, impressive finish. These studies do not discuss the colors to any great extent; but more could certainly be done along that line. An indispensable preparation for such work and also a corrective to it would be that old desideratum of the Hugo research: an exhaustive examination of his drawings, also from a typological point of view.[108] A thorough comparison with Goethe would also be of interest. He has been equally well analyzed and is at the same time similar to and deeply different from Hugo.

The multiplicity of contrasts during the beginning of the century continued through the following generations. No connected survey can be given here; the available material is scattered and fragmentary. A few examples of the main trends will have to suffice.

The counter-current within the Romantic movement was not in the first place called forth by Classical reminiscences. But everywhere it found support in the literary heritage; the new sober schools toward the middle of the century could use old slogans. In the field of color the turn of the tide is most obvious in the German Biedermeier-writers; their means of color expression have been especially well analyzed, and the growing realistic trend curiously mingles with Classical tradition. The development is exceptionally clear in the case of Büchner; in his works the tendency to Romantic light refraction and sparkling, dissolved hues openly struggles with a firmer, more realistic technique of description which points elsewhere.[109] The clash is equally manifest in Droste-Hülshoff and Stifter. Droste has been discussed in this respect by numerous scholars; particularly convincing is Weydt's book on her and Stifter together (890). Droste's use of color shows a gradual turn from Romantic tradition to Classical clarity and Realistic accuracy. This turn was not due to any optic myopy as maintained by earlier scholars but was a part of the conscious modelling of her technique of description which had a trend toward Impressionism but was tempered and tuned by Biedermeier's quiet and resigned attitude toward life. The Stifter-literature draws a similar picture (Bertram, 1060, Matzke, 1061, and again Weydt). Stifter, too, made his first attempts in Romantic colors but soon began to shade them off and tune them down till in his late works they altogether disappeared behind plane, line, and modelling of the light.

In its further development this new attitude of mind gave birth to modern Realism soon after 1850. But even the avowed Realists regarded the tradition with friendly eyes. The connection is manifest in England, and especially tangible in France. Actually, the French Classical color tradition never was broken, and made itself strongly felt during Romanticism itself, for instance in the preference for form and contour in Stendhal (Sagne, 581). "L'école de bon sens" was felt as a return to the natural and a victory for the national heritage. This interplay of Classical formula and growing Realistic observation is strikingly revealed in the colors of Leconte de Lisle (well described by Ditchy, 549, and Whiteley, 551) and the line can be traced even in the sculpture-like style of Heredia. At the same time the Parnassiens showed how Romanticism had become an inalienable inheritance as well. The Parnassiens often were Classical mostly in theory; in their practice they adhered to a Romantic exotism which seems quite remote from the ideals of sensible harmony. Heredia's style certainly is chiselled like that of a statue; but it is colored sculpture in polychrome stone. Equally curious is the oscillation between observation and tradition in the first Realistic novelists demonstrated by Demorest (503), Monnier (506), and Nowack (507) in the colorism of Flaubert—a confusing play of varying and partly conflicting demands. The picture is no less complicated in Balzac. The most interesting phenomenon of the whole period is perhaps the peculiar "school" linked to the names of E. A. Poe and Baudelaire who are closely related in their use of color.[110] A series of new and traditional features is welded together

[108] Escholier's book (527) does not go far enough.

[109] Lipmann (875), Winkler (877), and especially Majut (876).

[110] For Poe see Clough (707). For Baudelaire see especially Pommier (483), Rhodes (485), and Vivier (486).

by them into a mystical personal color style which has a general Romantic character but grips the reader with a magic charm of its own.

At the same time it was this period which saw the birth of an American color school of a totally different kind.[111] In the descriptive tradition which was founded by Thoreau and had its first master in Whitman there is the same mixture of Romantic and Realistic elements as in their European contemporaries. But there is added to it a freshness, a feeling of vast, virgin spaces, and a touch of exuberant physical strength which is as distinct from the traditions as Whitman is different from Poe and which was no less loaded with possibilities for the future.

Any unified advance could hardly be expected after these complicated operations around the middle of the century. If eddies and backwaters are disregarded, however, some main currents may still be distinguished.

Realism proper and its successor Naturalism have been rather neglected with regard to the study of color. A general survey is due to Dangelzer (430); there are a few books on Daudet (Henry, 498) and Maupassant (Urtel, 561), and the descriptive technique has been touched upon in connection with some other authors (e. g. Thomas Hardy). But much more interest has been devoted to those schools which toward the end of the century rose against Naturalism, and for obvious reasons: a fresh delight in the colors was reborn in them together with a new feeling for literary style.

One group within the movement tried to fill the demands by consciously reviving the historical color traditions as *Neo-Romanticism* or *Neo-Classicism*, frequently both in one. In the English field a good deal of research has been done with regard to Rossetti, representative of the extreme historical Romanticism. But it cannot be said that he and his school have yet been investigated according to their importance and their deep influence on later Anglo-Saxon taste down to this day. Within the literature in German language Stautner (1047) has shown in a subtle study how the "Munich School" mantled its semi-Classical ideology in an altogether Romantic color garb of a strangely mixed character. Some good work has been devoted to Detlev von Liliencron, a Romantic close to the soil.

Most interesting are the analyses of the strongly aesthetic and literary color school of the Swiss. Among them there are almost pure Classicists like Spitteler (Burkhardt, 1057; Meszleny, 1058). But their "Classical" trend runs parallel to a preference for the violent and greasy colors of Böcklin. The formulas take on a new meaning, often close to an extreme Romanticism, typical in Nietzsche with his color pomp, his taste for the warm hues, the twilight, and the diffuse lines and contours, mingled with his predilection for the blinding southern sunlight.[112] Deeply personal questions are raised by the festive and stately colors of C. F. Meyer: the analysis of the elements of experience and imagination in his sensorial world may contribute to the solution of the basic problem whether he really was a poet or only a clever literary stage manager.[113] Especially interesting is Meyer's relationship to the arts, and this holds good of the whole Neo-Romantic movement. A comparative analysis of the entire school in the art and literature of all countries, and of its traditions back to "real" Romanticism, is one of the *desiderata* of present color research.

The *Symbolist* reaction against Naturalism was more spontaneous. Of course it was linked to French poetry at the middle of the century; but it carried a less heavy load of tradition. A general survey of the use of color in the original French school is made by Hatzfeld (440), and there are also good analyses of some of the leading men, Verhaeren and Mallarmé (several studies), Maeterlinck (Kuntze, 556), and especially Verlaine (Fleischer, Schwachenberg, and Vogler, 586–588). Some of the most substantial comparative research work is focussed on Stefan George. In addition to the interesting studies by Baumgarten (901) and Zabeltitz (905), two comprehensive treatises by Sior (904) and especially Duthie (903) have traced in detail the connections that link George's color style to that of the French Symbolists. But the outstanding analysis of Symbolistic colorism is made by Miss Neddermann in her book on the Spanish poet Jiménez (414). She shows how Jiménez began in a Romantic isolation from the world but gradually developed into an Impressionistic discovery of the world, which finally was absorbed by Symbolism; she thus throws light on several types of style. Her most valuable analysis is devoted to the Symbolistic phase with its

[111] See Foerster (605).

[112] See Eckertz (1034) and Gross (1035).

[113] See Burkhard (1018).

trend of the oversensitive, indefinite, elusive, and immaterial, "infiltration of the soul into the sensorial impressions." Neddermann follows these trends all through the details of vocabulary and language, not only in the overwhelmingly rich use of epithets, but also in the function of the other word classes and in the syntactical structure. All the way the details of sensation are given their due part in the picture; and the book teems with subtle and striking interpretations.

The third movement which strove to replace Naturalism, *Impressionism*, was strictly speaking no movement of reaction but tried to deepen and intensify the Realistic means of expression and at the same time sublimate them. Impressionism has been *en vogue* in the literary research of recent decades; one early writer after another has been registered as Impressionist, from La Fontaine down. Many of these attempts—for instance, Carlowitz' efforts to make Goethe an Impressionist (912)—doubtlessly are overstrained; and even in authors after the middle of the nineteenth century caution is necessary. Impressionism proper has been characterized generally in several studies with good historical background (see especially Hamann, 804). The language style is analyzed in an excellent book by Thon (861). The problems particularly of syntax have been surveyed in the collection *El impresionismo en el lenguaje* (261), and play a great part in Thon's book as well. These studies of syntax have not only general interest as a background; the colors are an important criterion.

The ideal of Impressionism as contrasted with Naturalism was, not to reproduce the things themselves, but to render their transient impression in the moment when they pass through our mind "like pigeons in the loft" (Hofmannsthal). Only such elements of language remained which were able to seize and hold these isolated and unique flashes through the senses—in the color field, above all the adjective (as in Romanticism), not the root words, but the rare and unworn, special vocables which hit only one atomic point each so that many must be put together in order to create a picture. The style expressed an impotence in the face of the irresistible flood of sense impressions; the Impressionistic color style has a strong passive trend. The verb is little used and practically never in the active sense. Instead, those words dominate which describe a lasting condition, above all the nounized color adjectives, as mere color patches, put together side by side without verbs to link them. Often the style is vague on purpose, as the impressions may be themselves, with a violent accumulation of adjectives and a use of double words which mix several colors haphazardly in a way as to make the impression elusive, a motley, restless flicker. Often the color words are linked to other words in an altogether arbitrary way: the aim is no longer to give typical color, but value and shade. The same mixture of precision and unclarity is found in the numerous synaesthesias. This style is close to the pointilistic technique in painting, and there were intimate connections between writers and painters in the movement from the very beginning. Direct parallels play a considerable part in the literary analysis.

The general background of civilization was drawn into the picture in Reichert's (883) and especially Kunze's (882) analyses of Richard Dehmel. Kunze applied the Groos method and found a greater number of color shades in Dehmel than in any author who has been investigated. Within the French field the brothers Goncourt, "originators of the movement," have been analyzed against a broad background of contemporary art, including their own artistic activity in many branches. Particularly important is Sabatier's survey of their aesthetic theory as a background of their practical use of color.[114] Among the many other studies devoted to the colors of Impressionism there are also some important analyses of English authors: Spee's book on Kipling (684), Wilmsen's on Thomas Hardy (673), and an excellent study by Wüscher on Joseph Conrad (665).

Of great interest to the relations of literature and art is the connection between Oscar Wilde and Whistler which was already mentioned above. Here as elsewhere the sensations are a criterion of deeper trends. While Eichbaum (769–770) regarded Impressionism as Wilde's natural form, which he would have found even without the assistance of Whistler's color symphonies, Fehr (771–772) maintained with equal energy that Wilde only adapted himself to the new style, as he often did, without really being able to make it his own because it was averse to his nature as a writer. For this reason he never managed to emancipate himself from the pictures; as in his Japanese pastiches he borrowed

[114] 518—compare Koehler (515), Loesch (516), and Møller (517).

the technique of the paintings because he was unable to recreate anything similar in his own medium of expression. These contrasts have been further discussed by Schirmann (775) and especially Richter (774).

Among the currents which replaced Impressionism in the new century only *Expressionism* is sufficiently at a distance to be judged objectively. It is of major interest to the color development. The general psychological background was well drawn by Schneider (845) and the details of style defined extensively by Brösel (794), supplemented by Thon's book on Impressionism. The decisive difference between Impressionism and Expressionism is the urge for spiritualization in the latter, the free transformation of the visible world according to inner demands. Realism built a clear, lucid, and close-knit color world with plain, simple relations. Impressionism yielded to the vagueness of the sensations; Expressionism masters the world, and uses color as its sovereign means of expression. For the first time in the history of writing the Expressionists thus came to detach the colors from the objects of description, not by chance, but as a part of their literary technique.

In Expressionistic style the things move unaided—preferably large, level, and crude color planes in sudden, revolving speed, often according to a geometric pattern, creating a feeling of vague expansion in the space. The subjective symbolic value of the color is the decisive factor, often abstractly; the intensity is such as to make the carrier of the color disappear or become altogether accessory. The shades are submerged in a mass effect without substance or limit; in addition, they are often so unfamiliar that it is difficult to form a clear conception of them anyhow. The verb carries the Expressionistic color technique, as adjective and noun are the instruments of Impressionism; Expressionism is active and ecstatic creation, not passive reception. There are countless stages of transition between these styles, and no definite lines of demarcation can be drawn. Generally speaking, the color style turns Expressionistic when it forgets about the real colors of the things and "is only intelligible in a visionary way," with a spiritual content which leaves the visible world behind.

It is needless to explain how deep changes in color history are signalled by this style. The general points of view might certainly give good results if applied to the poets of previous periods; it is sufficient to mention Victor Hugo. As yet, however, little has been done of detailed research. One of the best studies so far is S. Hallar's analysis of the Danish writer Tom Kristensen (1113).

Here as elsewhere the results of color research thus are scattered and fragmentary. The analyses have the most different starting points and use heterogeneous methods. The elementary investigations are still undone in many fields. We are far from comparative surveys even of the great periods of style, still farther from a color history of the nations, let alone one of world literature. The study is only in its beginnings in spite of its many-sided history; there are more problems than results. But the field is fertile, a new-broken ground, where the methods of work are still under vivid debate and the contribution of each worker is clearly discernible. And the problems which again and again raise the discussion and keep the frontier moving do not belong in the periphery but are fundamental to all literary research.

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SYMPOSIA

on

PRESENT DAY SOCIAL AND ECONOMIC ASPECTS OF NATIONAL HEALTH

and

THE UNITED NATIONS EDUCATIONAL, SCIENTIFIC AND CULTURAL ORGANIZATION, AND AMERICAN PARTICIPATION IN ITS ACTIVITIES

Papers read before
The American Philosophical Society
Annual General Meeting
April 18, 19, 1946

THE AMERICAN PHILOSOPHICAL SOCIETY
INDEPENDENCE SQUARE
PHILADELPHIA 6

1946

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THE HEALTH OF THE AMERICAN PEOPLE
An Historical Survey

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(*Read April 18, 1946, in the Symposium on Present Day Social and Economic Aspects of National Health*)

BROADLY conceived, the story of national health includes the history of disease and of all those means by which a society endeavors to promote health among its members. Medical science, education, and practice, in combination with public health procedures, play the chief roles in the story; but in the background hover social conditions and attitudes that influence health for better or for worse. The state of public health is a major aspect of the life of any people. It has taken Americans long to realize that the health of nations is as significant as the wealth of nations, and that the two are inextricably combined in the complex which we call contemporary civilization. But the country is closer to a full realization of this than ever before in the national past.

We are living today in a transition period, in an era when government and other social institutions display increasing concern for the prevention of disease and for the adequate medical care of the American people. At such times a glance back at earlier experience may be helpful. Under relatively static conditions, history may serve only to whet the curiosity of readers: may function simply as a form of *belle lettres*. But in times of action, of transition, it has or should have utilitarian values. In considering present problems of national health, then, it were well to take our bearings from the past. This done, we shall be in a better position to chart the future.

Health and illness have always, necessarily, been of vital concern to individuals. Reading the papers of Colonial worthies in this country, one gathers that they were—at times—more concerned about current diseases than they were with Holy Writ or even with the rights of Englishmen. It is by no means easy to interpret today their vague clinical concepts or to follow their ancient terminology. In eighteenth-century bills of mortality, individuals were solemnly reported to have died from such conditions as "debility," "decay," or—more simply—of just "being found dead."[1] Patient translation of various labels, however, will reveal much the same endemic diseases as are now current, as well as others which we are usually spared. America was a melting pot for diseases, as Europeans, Indians, and Africans engaged in a free exchange of their respective infections. Europeans, accustomed to a large number of somewhat domesticated parasites, suffered least in this process—Indians the most. Pious observers considered it providential when Indian neighbors were removed by epidemics, but in all other respects disease was a serious menace to the early Colonies.

Most settlements reported salubrious conditions for the first few years, after which they were devastated by "fevers"—chiefly malaria, typhoid, and respiratory infections. This pattern was constantly repeated as settlement expanded, since it took time for men to infect innocent mosquitoes and the surrounding "airs and waters." So high was the death rate in these later years that some populations—such as that of seventeenth-century Virginia—displayed little natural increase for decades despite the high birth rate of the period.[2]

Gradually, through complex social and biological processes summed up in the term acclimitization, the mortality declined to a point where rapid population increase ensued. This was occasionally interrupted by devastating epidemics, such as the great outbreak of yellow fever at Philadelphia in 1793. Were an epidemic to produce the same mortality rate in this city today, it would occasion a loss of some 200,000 people in a single summer and fall. But such visitations, although terrifying at the time, did not seriously check population growth.

With the advent of the nineteenth century, interesting geo-medical phenomena appeared. By

[1] See, e. g., the Phila. bills of mortality for 1808.

[2] On disease conditions in the early Colonies, see works on the medical history of various provinces, e. g. those of W. Blanton on Virginia, of S. A. Green on Massachusetts, and of J. J. Walsh on New York. The earliest American writings on the theme seem to have been those of William Currie, e. g., *Historical account of the climates and diseases of the United States . . .*, Phila., T. Dobson, 1792; and of Noah Webster, 1799.

this time, malaria was declining in New England and the Middle Atlantic States, though it continued to plague the Middle West until after mid-century and remains serious in parts of the South to this day.[3] The latter section enjoyed relatively little decline in disease since its climate encouraged insect vectors and other parasites, its proximity to the Caribbean facilitated epidemic invasions from that area, and its standards of living remained relatively low. New Orleans, for instance, remained the "graveyard of the Southwest" throughout the greater part of the nineteenth century, and suffered an outbreak of yellow fever as late as 1904. During ante-bellum days life insurance companies charged higher premiums to those who lived south of the Mason-Dixon line.

Another geographical phenomenon of the nineteenth century was the apparent increase in urban mortality rates, as population migrated to growing commercial and industrial centers. Early growth of cities probably improved public health since paving and drainage inhibited insect vectors. But as cities attained some size this advantage was offset by increases in respiratory, intestinal, and venereal infections. "Consumption" was promoted by overcrowding, typhoid by the introduction of "modern improvements" that pumped bacilli into every home, and venereal diseases by the prostitution that has always been an urban phenomenon. Long hours of labor, unsanitary factory conditions, intemperance, and low standards of living in urban slums all played their part. In New York City, for example, the gross mortality rate for 1810 was reported as 1 death for every 46.5 persons; by 1859 this had risen to 1 for every 27![4]

Matters became worse in Southern cities during Civil War and Reconstruction, when many poor Negroes herded into slum areas and were for the first time systematically exposed to tuberculosis and to venereal infections. In 1860 the white death rate in Savannah was reported—in terms of population percentages—as 2.53, the Negro only as 2.32. By 1866 the white rate had fallen slightly to 2.12, but the Negro had risen to 5.96![5] It was feared that American cities, like earlier British industrial towns, would be able to maintain population only by continued migration from the healthier rural areas. Jeffersonian warnings against urban conditions seemed confirmed.

Colonial Americans had at their disposal, in the never-ceasing struggle with illness, a cumulative medical lore—most of it erroneous—and certain professional and institutional traditions—most of them ineffective. Although they dabbled in trial-and-error experiments with remedies, they inherited little urge toward original investigations. Real medical research flowered here and there in England during the 1600's, but remained too delicate an exotic to survive the Atlantic crossing.

Prior to about 1750 there were no Colonial towns large enough to follow European example in establishing medical schools, libraries, and hospitals. Indeed such institutions were rare until after 1820. Most of those who wished to practice medicine picked up the art through experience, by apprenticeship, or by reading such European works as came to hand. It was rarely feasible to distinguish between regular and irregular practitioners by any licensing procedure. Under these circumstances, actual practice was a fearful and wonderful combination of elements derived from European literature, practical experience, folklore, "kitchen physic," Indian practices, and unadorned superstitions. Generally speaking, it was customary to combine the ancient depletion procedures of bleeding, blistering, and purging with a resort to the grotesque pharmacopeia of the period. The more repulsive the remedies, the more potent were they considered. The first American patent medicine was an elixir of worms.

How far such medical practice had curative values may readily be imagined. In some cases it was undoubtedly dangerous, so that there were compensations in living beyond the reach of doctors. Nor are we likely, in this more secular age, to ascribe much efficacy to the religious appeals of the time. From a naturalistic point of view, faith in divine protection against illness had its values for morale; but over against these must be set the reverse effects of fear—fear of divine wrath, or of the occult influences exerted by an invisible world.

[3] Unusually thorough studies have been made of the history of malaria, notably O. W. Holmes' early work on New England; St. Julien R. Childs, *Malaria and colonization in the Carolina low country: 1526–1696*, Johns Hopkins Press, 1940, and Erwin H. Ackerknecht, *Malaria in the Upper Mississippi Valley, 1760–1900*, Supp. No. 4, *Bull. Hist. of Med.*, 1945.

[4] Bolduan, C. F., Over a century of health administration in New York City, *New York City Dept. of Health, Mon. series*, No. 13: 3, March, 1916; see also J. H. Griscom's statement in *Proc., 3rd Nat. Quar. and Sanitary Convention*, 241, N. Y., 1859.

[5] Duncan, W., *Tabulated mortuary record of the city of Savannah . . .*, 36, Savannah, 1870.

Of some significance, however, were empirical preventive procedures against infectious diseases. Medieval experience had emphasized the dangers of contagion, so that Colonial assemblies inherited the practice of establishing port and also local quarantines. Town authorities, for the same reason, set up pest houses and occasionally isolated individual homes. During the 1720's the first preventive medicine was imported from England in the form of smallpox inoculation based upon experience with contagion. This was followed, about 1800, by the improved version known as vaccination, which thereafter afforded protection against smallpox as far as an individualistic society would practice it voluntarily.

Meantime, between 1750 and 1850, a reaction gradually set in against the contagion hypothesis and in favor of another ancient theory of disease origins. This was the classical concept of poisons emanating from decaying animal and vegetable materials, transmitted by impure airs and waters. Such a view indicated sanitary reform rather than quarantines. Alarmed by outbreaks of yellow fever and cholera, and stimulated by developments in Britain, American municipal authorities established health boards, paved streets, drained marshes, built water works, and discussed better housing, ventilation, and the like (1800–1860).[6] Lemuel Shattuck of Boston urged, in 1850, that state health boards be set up with some authority to enforce health regulations despite the indifference of a laissez faire society. Seven years later Wilson Jewell, of the Philadelphia Board, inaugurated a series of national sanitary conventions which proved a precursor of the American Public Health Association. These conventions were notable in bringing doctors and laymen together in a voluntary body analogous to the British Health of Towns Association.[7]

The sanitary reform movement was paralleled by growing concern for personal hygiene. This had stemmed, in Europe, from the Enlightenment of the preceding century, and was made more feasible by sanitary improvements. The Saturday night bath was introduced as a real triumph for sweetness and light. Many popular health magazines appeared after 1840. Humanitarians like Sylvester Graham campaigned for dietary reform, condemning gluttony as others denounced drunkenness. His emphasis upon whole grains anticipated present vitamin enthusiasms, and is recalled today in such terms as "Graham bread" and "Graham crackers."[8]

While some stumbling advances were thus made in empirical hygiene, a revolution was under way in medical science. This was destined to provide therapy as well as hygiene with a rational basis which after 1875 would ensure more rapid and directed progress in both of these fields.

Briefly stated, modern medicine was made possible by two steps taken in European medical centers between 1750 and 1850. The first was the abandonment of the age-old and fruitless search for cures, and a concentration on the more significant search for diseases. Only after various forms of illness had been clearly distinguished could the quest for the causes, prevention, and cure thereof be undertaken in a rational manner. Speculative theories about an all-pervading humoral pathology, which indicated one cause of illness (blood impurities) and one cure (bleeding) were abandoned. Instead, disease entities were gradually identified by correlating clinical symptoms with the lesions found at autopsy.

Since such research called for more careful examinations, both at the bedside and on the autopsy table, the second step ensued in Paris after about 1820; that is, the methods of the physical sciences were finally applied to medicine. Instruments to aid the senses (the microscope, the stethoscope), quantitative procedures (pulse-timing, clinical statistics), and experimentation (as in physiology) were gradually introduced. There emerged an objective science, stressing a localized, structural pathology as the basis of specific disease processes.[9]

Americans contributed little to these scientific developments for reasons too complex to analyze

[6] For the story prior to 1860, see *Proc.* of the several National Quar. and Sanitary Conventions, 1847–1860; e. g., as cited above, note 4; and also the *Proc. Amer. Med. Assn.* for 1848–1850. The later story is interpreted in a series of essays in M. P. Ravenel (ed.), *A half century of public health*, N. Y., Amer. Pub. Health Assn., 1921. The most detailed study of a single city is that of W. T. Howard, *Public health admn. and the natural history of disease in Baltimore, 1797–1920*, Carnegie Institution of Washington, 1924.

[7] See *Proc.* of these Conventions, as noted above.

[8] Shryock, Richard H., Sylvester Graham and the popular health movement, *Miss. Vall. Hist. Rev.* **18**: 172 ff., 1931.

[9] Faber, Knud H., *Nosographic*, ed. 2, 28 ff., N. Y., Hoeber, 1930; Long, E. R., *History of pathology*, chap. 4 ff., Baltimore, Williams and Wilkins, 1928; Fosseyeaux, Marcell, *Paris médical en 1830*, 97 ff., Paris, Le François, 1930.

here,[10] but the results were imported to our medical centers—from France between 1820 and 1860, and thereafter from Germany. Curiously enough, this promising epoch in medical science was viewed by the populace as one of the most unsatisfactory in medical practice. Critical pathologists, in repudiating old remedies, had little to offer in their place. They largely lost interest in cures—in applied science. Meantime the average practitioner continued to overdose and bleed to a point where popular opposition was aroused. Medical sects like homeopathy and Thomsonianism arose, reviving the monistic pathologies and promising the pleasant cures that regular medicine repudiated. In turning to these sects, the public abandoned such licensing restrictions as a few states had set up. This trend was further encouraged by concomitant deterioration in the regular profession. Proprietary medical schools appeared in many cities and flooded the country with inferior practitioners. Hence, by 1840, the profession faced the first crisis in its public relations—the lack of confidence in medical science and practice[11] Something was done to save the regular guild by organizing societies, adopting "ethical" codes, and setting up the American Medical Association in 1847. But no basic solution was possible short of scientific discoveries which would actually prevent or cure disease.

Such advances were achieved, in French and German medical centers, at just the time when high urban mortality and low professional repute made the situation most discouraging in this country. The progress from specific pathology to specific etiology was an entirely logical one. Now that separate diseases were fairly well identified, search for causes and cures could be at last rationally undertaken. The role of pathogenic bacteria had been suspected for some two hundred years; they were revealed, after 1875, to be specific causative factors in a whole series of infections. This story, from Pasteur and Koch down to the days of Noguchi, is well known. But what of the consequences?

To begin with, medical bacteriology carried further the old effort to identify specific diseases. The earliest basis on which such identification had been attempted was the confusing one of symptoms. Then the correlation of symptoms with lesions had made for clearer identification, as a result of which the search for specific causal factors had become possible. Once these were found, causation became a third criterion for identification, which could supplement those of symptoms and lesions. The three stages in approaching exact identification, corresponding to the successive development of each of the criteria noted, may be illustrated in the case of respiratory infections. Originally, one spoke of "inflammation of the chest" (symptoms), and this was then broken down into "pneumonia," "pleurisy," and so on, (symptoms, + lesions). When the causal criterion could also be employed, pneumonia was further analyzed into "pneumococcic pneumonia" as distinct from "virus pneumonia," and the former —finally—into "types 1, 2, 3," and so on (symptoms, + lesions, + causal factors). How helpful it is to secure this sharper focus on a disease entity is illustrated, negatively, by the difficulties attending diseases which can still be identified only by one or two criteria. Examples may be seen in tumors (symptoms, + lesions,—causal factor), or the common cold (symptoms,—lesions,—causal factor).

While medical bacteriology was thus modifying scientific concepts, it also tended to change popular attitudes toward disease. It is an exaggeration to credit bacteriology with the major role in replacing supernatural explanations of illness, since this shift in outlook goes back to the Enlightenment of the eighteenth century. A naturalistic attitude was implicit and explicit in the sanitary reform movements, 1800–1860. Yet bacteriology undoubtedly supplemented these earlier trends, in releasing the popular mind from ancient fears and superstitions anent disease. The process is by no means complete today, but it has gone far since 1750.

In proceeding to the influence exerted by pathology and bacteriology on actual medical practice, surgery first commands attention. For surgery had been transformed by localized pathology even before bacteriology became effective. As long as

[10] Shryock, Factors affecting medical research in the United States, 1800–1900, *Bull. Soc. Med. Hist. of Chicago* **5**: 1 ff., 1943.

[11] Physicians were very conscious of this crisis; see, e. g., Paul F. Eve, *Present position of the medical profession in society*, 14 ff., Augusta, Ga., McCafferty, 1849, and the article entitled To what cause are we to attribute the diminished respectability of the medical profession in the estimation of the American public? *Medical and Surgical Reporter*, n. s., **1**: 141 ff., 1858. *Re* licensing restrictions, note C. B. Cartwright, History of medical legislation in the state of New York, *N. Y. Jour. Med.* **4**: 160 ff., 1845, and numerous other articles and editorials in the medical journals. For public interest, see The medical controversy, *U. S. Democratic Review*, whole series, **35**: 263 ff., 1855.

disease was ascribed to humoral impurities, there was little place for surgery in ordinary practice. One could hardly operate on the blood. But once a structural pathology developed, the removal of diseased parts was indicated. Surgery began to move from the periphery to the center of practice.[12] Seeking improved techniques, Americans discovered effective, general anesthetics in the 1840's; and two decades later Lister, following Pasteur's hints, introduced antiseptic procedures.

More far-reaching than surgery in saving lives, was the impact of bacteriology on preventive medicine. Bacteriologists, besides discovering causative organisms, learned much about their means of transmission. Typhoid could be prevented by assuring pure water and food; malaria or yellow fever by avoiding insect vectors. Vaccines could be prepared from bacteria which would immunize those unable to avoid environmental infection. And, if all preventive procedures failed and an infectious disease was acquired, there was hope of finding substances which would act against invading organisms without injuring the host. During the early 1900's Erlich announced salvarsan as such a cure for syphilis. For a generation thereafter, hopes for further progress in chemotherapy were disappointed, but in the late 30's came the development of the sulfonamides and of penicillin. Although there may be dissillusionment with these drugs in the future, as there has been with other heralded cures in the past, their use has so far reduced mortality in a striking manner.[13]

It would be a mistake, of course, to imply that all was plain sailing in medical research after 1875. Once found, the virus and rickettsial infections proved more difficult to deal with than did most bacteria. Even some of the latter, notably the tubercle bacilli, have resisted all efforts to obtain specific means of prevention or cure. Most serious was the failure to find the causative factors in major degenerative and chronic diseases. Yet medicine did make marked advances after 1900 against two types of non-infectious disease; namely, against those deficiency conditions associated with malnutrition and with endocrine disorders.

Progress was also made in overcoming certain limitations inherent in the early bacteriologic approach. This had naturally focused on invading organisms as the sole "causes" of infection, and had emphasized the specificity of diseases in relation to localized parts. Hence doctors centered their interests on curing particular infections and lost sight of the patient as a whole. This concept of specificity was basic to medical research, 1800–1875, but it could be carried too far. Subsequent findings in immunology brought out the role of resistance mechanisms in the host—as in phagocytosis—so that today a pathologist thinks of the "cause" of an infectious disease as "a relationship" between pathogenic organisms and the host cells. Since some resistance factors are non-specific in nature, their study brought attention back to the interrelationships of body parts and functions. Discoveries in malnutrition and in endocrine conditions, as well as in psychosomatic relationships, all pointed in the same direction. There was a partial return to eighteenth-century interest in the individual's "constitution"—in his total make-up. Doctors were urged to treat patients rather than diseases. They must promote positive health and not strive merely to cure specific illnesses.

While these scientific developments were under way, after 1875, vast economic and social changes were occurring. Industrialism brought the rise of big business, migration to urban centers, and a rapid increase of total population. In order to control more complicated social conditions, governmental functions were expanded; and this trend was reflected in public health as in other fields. State health boards were founded between 1870 and 1900, while city boards expanded their activities. County boards were gradually set up after 1905, though unfortunately some 40 per cent of these still lack the services of full-time health officers. Generally speaking, neither state nor local health boards are yet effective bodies in the poorer areas.

Meantime, there was a significant evolution on the federal level. Excellent work in medical research and in public hygiene was carried on by the Army Medical Corps after 1898. About a decade later the old Marine Hospital organization, now entitled the Public Health Service, began to assume the functions of a national health department. Under the direction of local, state, and federal agencies, empirical sanitary efforts were metamorphosed—in the prosperous areas—into modern public health programs.[14]

[12] Sigerist, Henry E., Surgery at the time of the introduction of antisepsis, *Jour. Missouri Med. Assn.* **32**: 169, 1935.

[13] Galdston, Iago, *Behind the sulfa drugs: a short history of chemotherapy, passim.*, N. Y., Appleton-Century, 1943.

[14] See the Ravenel volume, cited in note 6 above. There remains, however, a serious lack of concentration of public

Private initiative, nevertheless, remained of primary importance. Leadership in the public health field was often provided by voluntary health organizations, which in campaigning against specific diseases aroused public as well as professional support. A notable example was that of the National Tuberculosis Association, organized in 1904.[15]

Private leadership also made possible the final transit of the medical sciences to the United States. The concentration of wealth after 1890, whatever its ultimate consequences, was of immediate benefit to medicine. Certain millionaires provided, for the first time, substantial funds for independent medical research and for superior medical training. Early advances in these fields were made, during the 1870's and 80's, at Harvard, Michigan, and Pennsylvania. Then, after 1893, Johns Hopkins assumed leadership with its new school patterned on German models. A general reform of medical education ensued after 1910, precipitated by Flexner's able report but based fundamentally on the standards required by a truly effective science.

The same basic influence led to other professional changes. New methods in diagnosis, therapy, and surgery transformed hospitals from grim places for the poor into institutions possessing the most elaborate facilities.[16] Their needs, particularly in surgery, promoted the evolution of the trained nurse. Medical libraries expanded, and world leadership was assumed by the Surgeon General's Library in Washington. Practice was simultaneously modified by the rise of specialties —a development growing out of localized pathology and also from the increasing complexity of medical science in general.[17]

Progress in preventive medicine, surgery, and therapy, combined with rising standards of living and other social trends, brought about some drop in both specific and crude mortality rates even before 1900. Thereafter, as national statistics first became available, spectacular declines were recorded. Thus the typhoid fever rate, which for 1900–1904 averaged 26.8 per 100,000, fell by 1942 to only .6. The crude death rate for the national registration area in 1900 was 17.2 per 1,000; by 1940, it had declined to 10.8. There were parallel increases in life expectancy at birth, which is a more significant index of well-being. At the time of the Revolution this was probably about 35 years, by 1850 it was about 42, and in 1900 it was over 48 for males. Between then and 1942, the last index rose to 63.7, an increase of about 15 years during the very time when the full force of the new medicine was first felt in American society. The gains for females were even greater. By the 1930's, life expectancy at birth was higher in the United States than in any comparable country.[18]

There were, finally, some advances at later age levels, though these were by no means so marked. This increase in life expectancy does not give the complete health picture since it fails to reflect the incidence of chronic diseases. Mental conditions, for example, cause wide suffering but may not shorten the life span. On the whole, however, improved expectancy implies the avoidance of much illness and of early death; and so represents one of the major social achievements of the recent age. It can be credited, in large measure, to progress in the medical sciences.

The public was not always aware of satistical trends, but they became very conscious of the more tangible medical achievements. There was something dramatic about bacteriology, and this was even more true of the "wonders of modern surgery." Laymen were impressed by the techniques and equipment employed in hospitals, and were awed by the learning of the specialists. Popular attitudes toward the profession began to change after 1890. State after state revived licensing procedures. The patronage of medical sects declined. Larger and larger funds were invested by philanthropists and state governments in medical education and research. By the last decade popular regard for medical science and personnel was carried to almost sentimental extremes. This was illustrated by a series of moving pictures which idealized the medical profession—"Men in White,"

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health functions in any one type of agency, whether on the local state, or federal levels.

[15] Patterson, Robt. G., *Antecedents of the Nat. Tub. Assn.*, N. T. A. Historical Ser., No. 2, N. Y., Nat. Tub. Assn., 1945; and the forthcoming work under the same auspices by Mrs. Esther P. Ingraham, on the history of the pioneer Pennsylvania Tuberculosis Association.

[16] See the study of E. H. L. Corwin, *The hospital*, soon to be published by the Commonwealth Fund in the monograph series of the Com't. on Med. and the Changing Order, the N. Y. Acad. of Medicine.

[17] Stern, Bernhard J., *American medical practice*, in the same series as noted above, chap. 3, N. Y., 1945.

[18] See Mortality summary for registration states, *Vital Statistics—Special Reports, Bur. of the Census* **16** (2) : 9, July 8, 1942; also **19** (3) and **20** (2) of same series; *Population index*, Princeton Univ. and the Pop. Assn. of Amer. for July, 1944, 212, 217; Louis I. Dublin, Trends in longevity, *Annals Amer. Acad. Polit. & Soc. Sci.* **237**: 123 ff. for Jan., 1945.

"Women in White," "The White Parade," and so on. For a while, almost anything "in white" was good for box-office returns. Matters had changed since 1850 when even the newspapers had condemned the ignorance and "licentiousness" of young doctors. The medical profession had met the first great test in its public relations: popular confidence was restored.[19]

Unhappily, new difficulties arose at this point. Advances in medical science added greatly to the costs of medical service. As late as 1890 the costs of medical education were low and the price of technical equipment negligible. Fees were usually moderate, and most families could pay for the family doctor's calls. No other services were expected save in occasional surgical emergencies. In so far as the poor or isolated failed to secure medical care, moreover, neither they nor philanthropists nor governments worried much about it as long as there was no great confidence in medical service. Few were concerned, for example, about a lack of hospital care so long as most people were only too glad to stay away from those depressing institutions.

When medical progress finally transformed such indifference into a growing demand for professional services, the whole situation had changed. Medical education was now prolonged and costly, professional equipment elaborate and expensive. The fees of surgeons and other specialists became higher than those of general practitioners. Hospital charges soared as patients were served by various physicians, nurses, and other technical personnel. It was all well worth it if people had the money, but many did not. The more the masses desired expert attention, the less they could afford it. Thus, in the very act of overcoming public distrust by scientific advances, medical men unintentionally contributed to a new difficulty in their public relations—the problem of medical costs.

This problem was further complicated by economic and social changes. By 1930 the majority of the American people lived in or near urban communities. Here they lost touch with family doctors and became more dependent upon expensive hospital services. City workers became destitute during hard times, whereas farm folk had been more self-sufficient. Yet urban families did not desire medical charity. Was there some other means by which the medical care they now desired could be supplied? After 1915 the American Association for Labor Legislation advocated a compulsory health insurance program analogous to those established in Germany and Britain.[20] The return of prosperity after 1921 temporarily silenced such demands, but the depression of the 30's made them more insistent. With the development of group insurance, voluntary prepayment medical plans like Blue Cross expanded rapidly after 1938 and protected urban, middle-income classes from charges for catastrophic illness. But they usually did not provide complete medical coverage, and in any case did not reach the masses of rural people or the urban poor.[21] Consequently a strong movement developed, backed by organized labor, to include compulsory health insurance in an expanding federal social security program. Organized medicine opposed this vigorously on the grounds that it would limit the freedom of physicians and lower the quality of services. The issue is squarely before Congress at the present time.

The whole situation is complicated by other factors affecting both the quantity and quality of present medical care. Many rural areas have never benefited by medical advances. They lack hospitals and, for this reason, practitioners as well. Modern practice is based on hospitals, and doctors avoid areas without them. Some means must be found, perhaps the use of federal funds, for providing hospitals in rural communities which cannot themselves afford to establish them.

Meantime, both medical education and hospital services need to be reorientated by greater emphasis upon preventive care. The older objective of curing disease should be supplemented by efforts to promote positive health in individuals as well as for communities as a whole. The conquest of infectious diseases and the resulting increase in life expectancy, combined with a falling birth rate, has weighted the population heavily with the older-age groups. These are susceptible to the degenerative diseases which have consequently displayed a mounting mortality since 1900. Unfortunately, such diseases also seem to be increasing even

[19] Shryock, *Development of modern medicine*, chap. 16, Univ. of Penna. Press, 1936.

[20] Andrews, John B., Health promotion through legislation for health insurance, Reprint, *Proc. State Health Authorities*, N. Y., 1919.

[21] Avnet, Helen H., *Voluntary medical insurance in the United States*, 33, 1943. See also the study made by the U. S. Social Security Bd., Bureau Memorandum no. 55, *Prepayment medical care organization*, as analyzed in Margaret C. Klem, Voluntary medical insurance plans, *Medical Care* **4**: 263 ff., Nov., 1944.

within given age levels. Between 1910 and 1924, for example, the national cancer mortality rate rose 21 per cent for females and 47 per cent for males. Within just the five years between 1939 and 1944 this rate advanced from 119.3 per 100,000 to 129.1.[22]

As few means for the cure of degenerative diseases have been found, the chief measures available are inhibitory or ameliorative in character. These cannot, in most cases, be applied to masses, but must be provided to individuals as such. Health education, convalescent care, and rehabilitation are important factors here. All these circumstances demand that practitioners and other professional personnel, working both as individuals and through institutions, stress preventive and ameliorative care.

These services must include mental as well as physical hygiene, since mental diseases are among the chronic conditions which seem to be growing in disturbing fashion. Indeed, psychiatry deserves far more attention in medical education and practice than it has hitherto received.[23]

The forms of medical practice also need some overhauling in order to reconcile them with current scientific standards. Despite the undoubted merits of the family doctor, solo practice now has serious limitations. The general practitioner, to be truly effective today, must be in close touch with specialists. Hence group practice will probably prove more and more desirable in the future.

Last but not least is the basic need for an expanded program of medical research. Much as support for this improved after 1900, with the growing interest displayed by philanthropists, drug companies, and governments, present resources are plainly inadequate. The sinister menace of degenerative and chronic diseases constitutes a major challenge. Yet far more is still spent on research concerning infectious diseases as a result of the momentum acquired in this direction since 1875. Research needs to shift its emphasis and that right soon.[24]

Private resources will probably have to be supplemented by federal funds, in some such program as that of the proposed National Science Foundation now before Congress. This need is particularly urgent at present because the recent war demonstrated, in applied medicine, how much could be accomplished with large sums and concentrated effort; and yet at the same time this conflict—like all wars—actually held up fundamental investigations. Many scientists will oppose large federal subsidies, however, unless some formula can be found for reconciling these with freedom of research.

To sum up, the history of the nation's health over the last two centuries, and particularly for the last fifty years, affords many grounds for encouragement and even for legitimate pride. But the many and difficult problems now confronting us, some of them the unexpected consequences of earlier achievement, afford no excuse for the slightest complacency. The price of medical progress, like that of liberty, is eternal vigilance.

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[22] Dublin, as cited in note 18 above, p. 128; Heart diseases cause three deaths in ten, Bur. of the Census, special release, Oct. 21, 1945, p. 2.

[23] In no field is there such a wide disparity between the seriousness of the morbidity problem and the number of specialists qualified to deal with it. Among an estimated 180,000 physicians in the country, there are only about 3,000 psychiatrists—of whom not more than 600 are available outside hospitals; see testimony of Dr. Lawrence Kubie of Columbia University, Senate Subcom't. on Wartime Health and Ed., Hearings: *Medical Research* 1: 2229 ff., Wash., G. P. O., 1944. On the general history of the field, see Gregory Zilboorg (ed.), *American psychiatry*, Columbia Univ. Press, 1924.

[24] The extreme contrast is between the $.17 per death spent on heart disease research and the $525 spent per year for studies in infantile paralysis. Even if the figure for the latter is based on deaths plus all seriously crippled cases, it comes to $100. About $2.18 is granted per death in the case of cancer; Henry S. Sims, The future of medical research, paper read before Section L, A. A. A. S., Cleveland, Sept. 11–16, 1944. See also pamphlets issued by the Medical Memorial Fund, New York City.

MENTAL HYGIENE

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(Read April 18, 1946, in the Symposium on Present Day Social and Economic Aspects of National Health)

It does not require any alarmist to prove that the problem of mental hygiene is perhaps the largest and most pressing in the entire field of public health. That over one-half of the hospital beds of the entire country are in mental institutions, that over a quarter million persons are annually admitted to mental hospitals (of all types) and that the annual cost of the maintenance alone—disregarding capital outlay—of the public mental hospitals of the United States is at least $150,000,000, are facts which have been given added emphasis by the psychiatric experiences of the recent war.

Considerable currency has been given to the fact that over 700,000 men or 16½ per cent were rejected from the draft for reasons included under the heading of nervous and mental disorders (although many of these disorders did not materially disable the individual for civilian life) and that an additional 582,000 or 13.8 per cent were rejected for reasons which included mental defect. We have also been told that nearly 45 per cent of the disability discharges from the Army were for psychiatric reasons although as yet exact figures are not available. At times there has appeared evident a wholly unwarranted tendency to infer from these figures that a very large segment of American youth is suffering from serious mental disorder. We have no means of knowing, so early, what proportion of the men who were given psychiatric discharges from the Army will fail to make a good adjustment to civilian life. It certainly is to be hoped that, with understanding on the part of the families, reasonable expectation of employment, and the various advantages offered to returning veterans, most of these men will shortly again become useful citizens. It is a fact that, up to December 31, 1945, over 65,000 veterans of World War II had been admitted to the psychiatric hospitals of the Veterans Administration and that on that date there were 12,274 patients from World War II under care in those hospitals, a total of 43 per cent of all the World War II patients in Veterans' Hospitals. The same figures, however, show that in the same period 53,000 or 81 per cent of these very men had been discharged from hospital care. It is reported, likewise, that the peak of the admissions to Veterans' Hospitals from World War I has not yet been reached, and that the psychiatric hospitals of the Veterans Administration are already filled to capacity.

These facts and figures, whether or not they cause alarm, certainly evoke attention. Furthermore, there is every reason to believe that there are at least fully as many persons outside of hospitals who, although not requiring hospitalization, are substantially disabled by neurosis, and there are certainly countless others who exhibit numerous and serious physical complaints which are essentially of a psychiatric nature. The problem of neurotic disorders, in short, is a substantial and serious one. There are, however, no reliable statistics concerning the non-hospitalized psychiatric patient.

Despite the evidence of the magnitude of the problem of mental disorder, it is a curious fact that psychiatry is a recent newcomer to full recognition by the field of medicine, and that mental disorder has long been relatively unrecognized in the field of public health. Indeed it is doubtful today whether the administration of the mental hospitals of any state is vested in the Department of Public Health; nearly all of them are operated as charitable institutions under the supervision of a Department of Public Welfare or its equivalent. A full understanding of the reasons for this neglect would involve a recapitulation of the entire history of medical psychology, but a few factors may be mentioned in passing.

First of all, from the time of primitive man until about the eighteenth century, there has been a belief in what may be termed the demonological nature of mental disorder, with the result that even nowadays many persons have a horror of mental disease and the mentally ill which they cannot explain on logical grounds. From the time of the dark ages until the French Revolution, when

Pinel and Esquirol in France, and in this country our own Benjamin Rush emphasized the medical nature of mental illness, it was chiefly the philosopher, the theologian, and the jailer who had to do with the mentally ill. By reason of the fact, too, that in the early days of this country it was only the "furiously mad" and paupers who were eligible for care in mental hospitals, the institutions tended to remain custodial in nature. Again, the need of legal justification for the detention of the mentally ill in the form of commitment procedures has set up distinctions in law between general and mental hospitals, and thus tended to emphasize the separateness of psychiatry.

There has been, throughout the ages, a tendency to dissociate the mind and body, to look upon the problems of the two as entirely distinct, so that many physicians have been inclined to pride themselves upon the fact that they know nothing about mental disorders. Perhaps full recognition was not given to psychiatry until immediately after the close of World War I—certainly a great impetus was given by that conflict, an impetus which has been tremendously reinforced by the experiences of medical officers in the Army and Navy during the war just closed. Many physicians have, from personal observation, learned for the first time that the problems of general medicine are, to a considerable extent, psychiatric in nature, while the psychiatrist too has learned much about psychosomatic medicine.

The greatest single contribution to the advancement of psychiatry in the present century is unquestionably the work of Sigmund Freud, without whose genius we might well still be groping in the relative darkness of descriptive psychiatry. The contributions in this country of such psychiatrists as Brill, Jelliffe, White, and Adolf Meyer, and of the physiological school led by the late Dr. Walter B. Cannon, have done much to bring about the development of the modern concept of mental disorder. Today psychiatry has far outgrown the scope of the mental hospital where it originated. It views man as a being who, for various reasons, may fail at the social level to adjust to the demands of environment. The mind itself it looks upon as an abstraction, a term used to denominate the totality of the integrative mechanisms which are aimed at the adjustment of the individual to the demands of his environment. This functioning is dependent upon a physical organism, to be sure, and for that reason the manner in which that organism functions is important. How the various organs perform their duties has a bearing upon how the individual as a whole is able to meet the demands of the environment, and thus the internist and the surgeon can no more overlook the mental attitude of their patient than the psychiatrist can overlook the significance of pneumonia or a tumor.

Man must do more, however, than live with himself; he must live with others. He is subject to demands of various sorts upon him—academic, social, economic, military, domestic. Furthermore, these pressures may cause defects in adjustment which manifest themselves through the autonomic nervous system in various physical complaints. This is a fact which was well known by the family doctor one hundred years ago, but which has tended to be overlooked during the rise of overspecialization. It is a truth which is just beginning to be rediscovered under the formidable name of psychosomatic medicine, a term which serves to emphasize what should be the proper attitude of every practitioner of the medical art, namely, the recognition that he is dealing, not with a single organ, but with a human being who, far from functioning in a vacuum, is laboring under various and sometimes difficult environmental stresses. Perhaps enough has been said to indicate that psychiatry is an integral part of medicine. That is the way in which it is being presented today in the more progressive medical schools, and we may look for further substantial advances in the manner of teaching psychiatry.

In the causation of maladjustment at the social level it is obvious that there must be numerous factors operating and that, since every experience of the individual has its place in conditioning future reactions, the history of the patient is important. Much was formerly said about the role of heredity. Recent careful studies, particularly by Kallman, of New York, have indicated that there is a definite "loading" in certain types of mental disorders, that is that, in certain families, mental disease tends to occur with greater frequency than would be indicated by the laws of chance. The emphasis on heredity, however, is still relatively slight, and, far from being looked upon as an evidence of inevitability, it is considered a challenge to more vigorous preventive work.

Far more important than heredity is the factor of childhood experiences. Indeed, these are probably the most important single factor in mental balance or imbalance. Parental neglect or rejec-

tion or, what sometimes proves even more malignant, maternal over-protection, are samples of the sort of thing which, although deeply buried in the unconscious, may be highly significant in conditioning attitudes and may result in lines of cleavage, so to speak, which may become manifest, years later, when the adult is placed under stress, whatever the nature of that stress may be. We are indebted for our knowledge of this factor largely to the work of Freud, a knowledge which has been amply confirmed through studies in the child-guidance clinics and in the schools.

Damage to the coordinating apparatus, that is, the central nervous system, or indeed damage to any part of the organism, whether by intoxication, disease, new growth, or the degenerative processes of advancing years, may be a substantial factor in weakening the ability to adjust. In this connection one thinks of the mental disorders due to syphilis and those caused by alcohol or manifesting themselves in an excessive use of that drug, and those arising in the course of various other disorders of the nervous system. As for the other organs of the body, the effects of generalized infection in causing delirium, and the various abnormal mental states of milder degree which frequently accompany disorders of the various organ-systems may be mentioned.

I should like particularly to invite your attention to the role of advancing age as a factor in mental disorder and the important corollaries which derive from the fact that the proportion of older persons in the population is steadily and rather rapidly mounting. Thanks to the marked reduction in infant mortality, the practical abolition of epidemics and diseases such as typhoid and diphtheria, and the reduction in fatal accidents, we find that, whereas in 1900 approximately 4 per cent of the population was over sixty-five years of age, and at present approximately 6½ per cent, we may expect that by 1980 about 14 per cent of the population will be found in that age group. Dayton, through his significant researches into the statistics of mental disorder, has demonstrated effectively that with the failure of the physiological processes in the later years of life there is an accompanying increase in the incidence of mental disease. The incidence is not steady in progress; there is a marked upward trend to the curve at about age sixty, and the parallelism between a graph showing the rates of admissions to mental hospitals by age groups on the one hand and the death rate on the other is striking. Failure of physiological processes is not the only factor; numerous psychological factors operate in the case of older persons. The fact remains, however, that mental disorder is essentially a disease of advancing years. What is more, it seems not unlikely that the actual rate within the group is increasing. Malzberg, who has done some valuable statistical work in the New York State service, has figured the expectancy of the incidence of mental disease—that is, admissions to a mental hospital per one thousand population for each year of life, for the years 1920, 1930, and 1940. For example, the corresponding rates per one thousand at age fifty for these three ten year intervals are as follows: 33.4; 44.7; 57.2. The importance of the increasing rate of mental breakdown in the later years of life, hitherto disregarded in the planning of the social administrator, can hardly be emphasized too seriously.

As progress has been made in the understanding of the nature of mental disorder as an aspect of the functioning human organism, advances have likewise been made in the line of treatment and prevention. Many of these have come along in the last few decades and have substantially altered the prognosis of numerous disorders; they hold much promise as well for prevention. For example, the campaign against venereal disease, which began at the end of the last war and which has been greatly developed during the past few years, is now at last having its effect in lowering, among other things, the rate of admissions for general paresis. As time goes on, it may be expected that this particular disease, which is one of the late manifestations of syphilis, will become even less frequent. At the same time, the treatment by malaria, first described by Wagner-Jauregg in 1918 and first employed in this country at St. Elizabeth's Hospital, Washington, D. C., has revolutionized the prognosis of general paresis, with the result that now there is every assurance that a case recognized early may be at least promptly arrested.

The advance in knowledge concerning the role of the vitamins has had its effect upon the treatments of the disorders due to alcohol and the senium. Some of the so-called alcoholic psychoses respond promptly to vitamin therapy, and the same is true of some of the acute confusional states in the elderly.

The further understanding of the mental mechanisms of the psychoses and the neuroses, mild and severe, has laid the ground work for more effective psychotherapy. This has been defined by Whitehorn as "the art of modifying the patient's atti-

tudes in a more healthy direction by the personal influence of the therapist." Formal psychoanalysis, as developed by Freud, has demonstrated its value in selected cases of the neuroses, and various modifications of the psychoanalytic technique are being developed with much effect. There are numerous types of psychotherapy in addition to psychoanalysis although they are all based fundamentally upon the understanding of the mental mechanisms given us by Freud. Many of the minor maladjustments are readily corrected by the patient with a modicum of guidance from the psychotherapist. This is far different from "self-analysis," however, against which a warning should be uttered. The impression is sometimes given that the patient who is suffering from various anxieties or phobias may, if he reads the right books, cure himself. It is, in the last analysis, in any disorder, the patient who exhibits the process of cure, but in this, as in many medical and surgical conditions, the aid of the physician is an essential part of the process. This is especially true in emotional maladjustments. Much harm is done in this field by quacks, and much unhappiness is caused to the sufferer who hesitates to see a psychiatrist because he fears the alleged "stigma," preferring to "battle it out" alone—often with resultant aggravation of his symptoms. Psychotherapy need not always be a long process, but it can often cut short a long period of suffering and misery.

Particularly as a result of psychiatric experience during the war, various types of group therapy have received new support. The advantage of economizing the time of the therapist is obvious, but in addition there are certain supports derived from the group which cannot be readily secured from any one person. The psychodrama of Moreno is one example of group therapy which has demonstrated its value.

Another of the forms of treatment, of which much has been heard as a result of World War II, is what has been popularized under the name of narco-synthesis. This method, first described by Lorenz and Bleckwenn, in 1930, reinforces the psychotherapeutic technique by the use of a sedative drug (sodium amytal or pentothal sodium) which renders the patient more accessible. The value of the procedure has been thoroughly proved both before and during the war.

Much has been heard in the last few years of the so-called drastic, or shock, therapies. Although insulin therapy still has its advocates, the most common type today is electro-shock. There is nothing new in the principle of shock therapy, for it has long been known that, for some reason or other, a sudden shock, emotional or physical, sometimes has a beneficial effect upon a mental disturbance. What is new is the development of a method of administering a severe physical shock by means which are relatively safe and can be readily controlled. The method is an empirical one, but it seems clear that, in a very considerable number of cases, especially of the depressions, the course of the attack has been shortened; there are, however, some suggestions that remissions are somewhat more frequent than in the case of patients not treated by this method. The procedure is certainly not a panacea, and it is not entirely without its dangers; neither should it be depended upon alone. Psychotherapy should be employed in conjunction with it if the best results are to be expected.

An even more drastic method is that known as prefrontal leucotomy, a relatively simple operation by which certain fibers in the so-called prefrontal area of the brain are severed. This operation brings about a change which is not reversible; although it relaxes tensions, it also tends to bring about an abolition of the faculty of foresight. It should not be recommended except in patients who are no longer young, who have been resistive to the consistent application of other forms of therapy, and whose prognosis appears to be poor.

What of the curability of mental disorder? Certainly the accomplishment is far greater than is generally assumed. Every clinician in private practice knows that many psychiatric patients in the community are readily responsive to treatment, but here statistics are not readily available. As for the mental hospitals, which receive the most marked cases, the figures are encouraging. During 1943, the last year for which full reports are available, 82,650 patients were admitted to the State Hospitals (excluding the various other types of mental institutions such as psychopathic, veterans, county, and city hospitals), while during the same period 67,377 patients were discharged—81.5 per cent of the number admitted. By far the most of these patients were recovered (30.8 per cent) or substantially improved (58 per cent). Recently the Bureau of the Census has adopted the practice of figuring discharge rates not on the number of admissions but on the number of patients under care during the year. From 1934 to 1943 this rate for State Hospitals rose from 110.1 to 125.1, or 13⅔ per cent. These figures are not comparable with those exhibited by general hos-

pitals—the problem is a far different one from that with which the latter deal—but they certainly refute the popular misconception to the effect that mental disorder is incurable! They indicate likewise that progress is taking place in the results of treatment.

The various methods which have been mentioned, although applicable in hospitalized patients, are for the most part likewise useful in persons whose mental difficulties are of far less severe grade than to call for their care in an institution; this is notably true in the various kinds of psychotherapy. It should always be emphasized that the majority of persons who have conditions which call for consultation with a psychiatrist do not require care in a hospital, either for a shorter or a longer period, and that in any event early treatment of emotional difficulties is to be urged in order to forestall the necessity of later hospitalization.

In the field of preventive measures the place of the child guidance clinic seems secure. These clinics, in which psychiatrists work in close contact and cooperation with social workers and psychologists, deal with the problem of the child and the situation which has shown itself to be a factor in his emotional problems. This often involves the treatment of the family who sometimes are far less cooperative than the child! That these clinics are of value in aiding early maladjustments and thereby preventing later and more severe breakdowns seems clear. The institution of psychiatric programs within school systems, the routine examination of the children who are found to be mentally retarded or who are obviously having difficulty with their studies, and the institution of programs of elementary mental hygiene as a part of the health curriculum of the school are all factors in the better adjustment of school children to the problems of life, both in school and later. In the field of adult education the development of hobbies and intellectual interests should be encouraged, particularly for older persons, as a means of contributing to that zest for life which is the antidote of senescence.

The development of industrial psychiatry, which aids the fitting of the worker to his job and the maintenance of his efficiency, should reduce the incidence of maladjustment. This is a field which promises much for the future and which appears to be developing rapidly.

Likewise important is the development of a further recognition by the general practitioner of the psychological factors in disease. The psychiatric needs of the country can never be met by psychiatrists alone. The recognition of the human being as such should not be limited to the psychiatrist, but should be exercised by the medical practitioner, whatever his specialty.

There are needs for the future which can add much to the mental health of the nation. Even though the majority of patients who require psychiatric care are not in hospitals, the fact still remains that institutions are with us and probably will be for a long time to come. They have ever since the beginning been operated almost exclusively by the state, with varying degrees of success, although that success has sometimes been far from conspicuous. A study of the appropriations, for example, indicates an astonishing variety of legislative generosity. According to the latest reports, it appears that, whereas the most expensive public institution in the United States expended, in 1943, $723 per capita, there is a state —mercifully to be unnamed—which expended $180 per capita, or about fifty cents per day! The average for the United States in that year was $335, or a little less than one dollar per day. Many of these institutions are under-manned, the care is often largely custodial, and in some cases the appointment of medical and other personnel is dependent upon political considerations. The public mental hospitals (and about 98 per cent of the hospitalized mental patients are in them) should be operated on the merit basis, under medical auspices and adequately staffed and equipped for modern treatment; in states having several hospitals there should be a coordinated system of administration, also under experienced psychiatric supervision. These institutions today are medical, and should no longer be classed along with infirmaries, institutions for juvenile delinquents, and other similar non-medical welfare facilities. The institutions could well be used as the nucleus of a wide net of out-patient clinics. Facilities should be made readily available for the rendering of early psychiatric service to the numerous persons who would profit by it in the community while still at home, and in many cases while still employed. The investment would yield substantial dividends as a preventive of severe breakdowns.

General hospitals more and more are tending to set up psychiatric wards. This arrangement has numerous advantages. It avoids the commitment of patients to mental hospitals, tends to break down the artificial distinction between psychiatric and other disorders, and contributes to a further understanding of the place of psychiatry

in the field of general medicine. It should be no more difficult, legally or in any other way, for a patient to receive care for a mental disorder than it is for any other sort of disability, and the laws of the several states should reduce to a minimum the formal requirements for such care. In the field of mental deficiency, which is partly educational although primarily psychiatric, an attempt should be made to insure the early recognition and training of the mentally retarded child. This will mostly be in special school classes, rather than in institutions.

The relationship of mental defect and disorder to delinquency and crime, though often exaggerated by sensational writers, is none the less real. A program of this sort administered by psychiatrists should eventually be reflected in the crime rates. In addition, the possible contributions of psychiatry to the functioning of the courts and correctional institutions are only beginning to be recognized.

The training in medical schools and in postgraduate circles is well on the way to improvement. Psychiatry is no longer being taught as an isolated specialty, but as an important part of general medicine. As the present medical students and the physicians just returning from military service go into practice we may expect a far higher grade of psychiatric service, in general, than has hitherto been available.

Finally, research into the nature of mental disorder, its causes, its treatment, and its prevention, should be more vigorously pressed. In the past the support which research has received in this field has been meager indeed compared to the size of the problem. Much work has been done in a number of centers by men who are competent, who have imagination and training, and who have the urge to carry on investigation. Such men deserve moral and financial support in whatever places and under whatever conditions they may choose to work.

Enough has been said to indicate that mental hygiéne, using that term in its broadest sense, is one which is interwoven with the daily life of many of our fellow citizens. It not only permeates the field of general medicine but ramifies into the school, the factory, and the court. Despite ancient prejudices, much progress has been made in understanding, treatment, and prevention, and, as a result of the added demonstration of the value of psychiatry in the recent war, we may during the coming years safely look for a greater sphere of influence and a closer contact of mental hygiene with the health and happiness of the people of this country.

ROLE OF GOVERNMENTAL AGENCIES IN A NATIONAL HEALTH PROGRAM[1]

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(Read April 18, 1946, in the Symposium on Present Day Social and Economic Aspects of National Health)

I

BEFORE we inquire into the role of governmental agencies in a national health program, we should be clear about the meaning of the term "national health" and the phrase "a national health program."

Until a decade or so ago, "national health" and "public health" were largely synonymous expressions. They elude precise definition, but traditionally they referred to the well-being of the nation as reflected mainly in the control of epidemic disease and the provisions for environmental sanitation, and as measured by the death rate. Today we use these terms in a broader sense—to express concern with the physical and mental well-being of the individuals and families that comprise the nation, as well as with the aggregate of community health.

Gradually, in the years between the two World Wars, it came to be recognized that most sickness and most deaths in our times result from causes that we cannot control by available preventive measures. It began to be appreciated that the diseases which cannot be prevented from occurring need early detection, accurate diagnosis, and prompt, comprehensive, and continued care; that the death rate is a crude and inadequate index of morbidity; and that illness and disablement are more prevalent than they need or should be. Today, the proper measure of the "public health" is the state of health of the living—not the count of the dead.

In the same years the public learned of the new and enlarged possibilities for health, and it began in countless ways to demand a share in these opportunities. In part, this newer demand was in the traditional patterns of "public health," with primary concern for premature mortality and community-wide preventive services; in larger measure, however, it was in the newer patterns of social security, with emphasis on assurance of medical and hospital care needed by individuals, and on protection against the economic burdens of sickness, disability, and dependency.

Out of these trends has come an emphasis on "national health," not broader in true meaning but much broader and deeper in proposed practice than had been embraced by the term "public health."

In its present connection a national health program first attained definite stature at the National Health Conference of 1938. A somewhat modified program was suggested by President Truman last year. I use his formulation, in its general outlines, to give specific meaning to the phrase "a national health program" today. Such a program for our times can be summarized in five categories:

1. Federal financial and technical aid to the states for the construction of needed hospitals, health centers, and other facilities;
2. Increased federal aid for state and local public health and related services;
3. Federal financial aid for scientific research and professional education;
4. Comprehensive provision for the prepayment of medical costs through national health insurance; and
5. Comprehensive protection against loss of wages from sickness and disability through expansion of our national system of social insurance.

These are benchmarks for a discussion of the role of governmental agencies in providing for the national health. For our present purposes, it will be useful to depart from the sequence of the President's five points; an inspection of administrative roles does not, in general, follow just this pattern.

II

We will gain perspective by reviewing briefly the emergence of our modern public health program. This chapter of our history shows how government in our democracy, as an interpretation of the needs and the will of the people, has

[1] The opinions expressed here are those of the author, and do not necessarily express the views of the Social Security Board or the Federal Security Agency.

responded to evolutionary change in the concept of "public health." From the old restricted functions of government, limited to holding vessels in harbor until they had been inspected for yellow fever or other communicable disease, to the growing recognition of the need for planned provisions against each case of disease, regardless of its origin, we have a story of public machinery changing in design to meet the changing needs of the times.

For a long time the state was the unit of government considered primarily responsible for the public health. But the states were in large measure backward in promoting the public health. It therefore fell mainly to local government to take action against menaces to the health of the community. In general, the pattern for improving the public health was to take positive action only after a serious problem had developed.

Gradually, one by one, the states developed codes of public health, all different but finally achieving many elements of uniformity. State interest led in a number of cases to financial contributions to communities, in return for which the state usually required observance of certain standards applicable to local public health work. Some pooling of resources within states tended to bring poorer communities up to a level of achievement beyond their own means. However, the variations among the states persisted because the states' individual provisions for the public health depended as much on their relative wealth as upon their needs. Thus, while the richer states were able to develop relatively effective measures for community-wide control of disease, the poorer states—whose health needs were in general greater —continued to have large unmet needs. These variations among states have been reduced somewhat owing to federal assistance; but this is a comparatively recent development.

The federal government agency chiefly concerned with public health is the (U. S.) Public Health Service. This agency began with the enactment of a national bill in 1798 to provide for sick and disabled seamen by means of regular small deductions from their wages and by the establishment of marine hospitals. At first limited to this function, under a name appropriate to its duties, it gradually acquired additional functions, particularly in connection with quarantine regulations. However, it was not until the second decade of this century that the activities of the Public Health Service were greatly broadened. Then it undertook extensive surveys of the health of communities (1913) and demonstrations in rural sanitation (1916). The chief effects of these efforts were an increased interest of the states in their own public health work and increased appropriations by states to localities.

The greatest stimulus to the work of the Public Health Service among the states derived from the same source as the states' progress among localities: money with which to carry on public health activities. Nevertheless, it was not until 1935, by means of the grants-in-aid under the Social Security Act, that allotments to states for general public health work became a regular procedure. Since then, grants have been made to the states on the basis of population, special health problems, and financial need. The conditions under which federal aid is given do not involve direct control of state activities. Although the federal grants have been comparatively small, they have been used to fill gaps and have served to expand the scope and improve the level of performance in states and localities. The Public Health Service carries on some direct activities (in addition to research and training of personnel), but its main functions, with regard to the states, are to make grants-in-aid, to give technical aid, and to lend trained personnel.

Thus, the present setting from which we must operate to advance the nation's health is complex. Of a total of 3,070 counties in the continental United States, only 1,828, or 60 per cent, had provision for full-time local health work in 1942. The population of the counties not having a health agency of even minimal adequacy amounted to about 40,000,000 persons. The obverse of this picture is the multiplicity of health agencies in some communities, especially the large cities and the metropolitan areas.

The picture is further confused by the lack of integration of health activities at the state level. No state has a single agency responsible for the administration of all public health work. Even within state health departments the administrative structures vary so that there may be units of organization devoted to the control of specific diseases, or to the problems of special population groups, or to the operation of particular classes of facilities, or to specialized devices for inspection, sanitation, etc. These complexities of administrative organization may often be traced to the ways in which funds were acquired for specific purposes with a consequent establishment of separate divisions of the health department, or of some other state department, for the administration of

those funds. Probably a great deal more money has been spent beneficially, in the aggregate, by this categorical method of obtaining funds for specific purposes than would have been spent if there had been a better planned and more homogeneous expansion of public health budgets.

However, this spasmodic annexation of new functions has created forty-eight highly individual and complicated state public health programs. Left largely to their own devices, some states with little prodding from below and little prompting from above have developed only the most rudimentary public health agencies. Other more active and wealthy states have a wide variety of well-developed government health functions. In general, it is safe to say that a state with an undeveloped or under-developed health program is usually a state poor in economic resources and, as a corollary, in medical personnel and facilities.

With regard to lack of coordination of health functions, some of the same difficulties prevail at the federal level. Although the Public Health Service is the chief federal agency for civilian public health activities, there are many government departments or agencies with some secondary responsibility in health. Here, too, are found the artificial segregations of population into age, sex, occupational, and other groups for the administration of health programs. Vital statistics, inspection of foods, nutrition, maternal and child care are some of the functions, properly a part of a health program, that are distributed among federal government departments. This distribution has its origin, too, in a succession of separate developments or temporary expediencies which time has made into semi-permanent arrangements. Some of the allocations have good reason, especially since particular health functions have integral relations with other responsibilities of government. A beginning toward some administrative consolidation was effected in 1939 when the Federal Security Agency was created; and more is in sight for the near future.

However much fault one may find with this organizational structure at each level of government, what we have is the system with which we have to work and from which we must establish our points of departure. This is the basis for the proposal that in a national health program, appropriate to our time and circumstance, the first two, and in part the third, of the five proposals (financial aid for facilities, for public health services, and for research and education) should be implemented by grants-in-aid from the federal government to the states—and through the states to the communities of the nation.

III

In spite of an increasing scope of public health activities developed within the last decade or two, government health programs for the general population—at every level of government—continue to be limited essentially to preventive measures. Even when medical care is given to an individual at public expense, the determining reason is usually the need to control infectious disease that might be communicated to others in the community. The outstanding exception to this rule is the medical care given to those accepted as wards of the state for reasons of poverty, crime, or mental breakdown. But health programs that touch the majority of our citizens are in general limited to preventive measures, and mainly to such as can operate through community-wide rather than personal services.

It has been traditional that, when an individual developed illness, it was left to him to find the medical care he required. A needy person, recognized by the community as not being able to provide for himself, could get care at some public facility—if he happened to live in a community that provided such facility; but the ordinary self-supporting individual made his own arrangements. Major or prolonged illness might tax his financial resources to the point of personal or family disaster, or considerations of cost might prevent his getting the care he needed. But, in the prevailing climate of opinion, these were regarded as his misfortune or the consequence of his own improvidence, and he was left to shift for himself.

However, such misfortune or lack of foresight was sufficiently common to give rise to a number of voluntary insurance plans. Most persons dependent upon current earnings do not have sufficiently elastic budgets to meet the variable costs of unexpected illness. And the fact remains that, on an individual basis, illness is almost invariably unexpected, and the amount and the costs of medical care needed are indeterminate. For large groups, the incidence of illness and the average cost of the needed care can be predicted with considerable accuracy. Taking advantage of the magic of averages, large groups of persons can contribute small sums of money to a common pool, and those of the group unfortunate enough to be stricken with illness can have access to this pool to meet the costs of medical care. Insurance against medical costs operates on this principle.

The practical test of an insurance system is not its good intentions but its achievement in population coverage and in the protection it furnishes. By these criteria voluntary health insurance has failed—in the United States as in every other country that has tried it. Since enrollment is voluntary, it is exposed to adverse selection of risk. It must therefore protect its finances through high premiums, selection of the participants, exclusions in the scope of protection, and "fine print" limitations in the contract. As a result, it fails to reach those economic groups that need protection most, or it keeps the premiums within their means by furnishing only limited protection.

While voluntary insurance has taught the world how to operate (and how not to operate) insurance against medical costs, it has also demonstrated the need for a more effective institution to meet a common public need.

The broader the coverage of a medical-care insurance plan, the more widely the risk of illness is spread, and the more completely the program can utilize the full resources of society. This is the outstanding advantage of developing a prepaid medical care program through compulsory social insurance, and preferably at the national level. For if every one, or nearly every one, in the nation is included, premiums may be at a minimum and benefits at a maximum.

IV

Out of the nation's two most recent cataclysmic periods, the economic depression and World War II, has grown a new emphasis on the function of government as an agent of the people, in their service, and a new balance of cooperation among the different levels of government. The sharing of national disaster developed into an unprecedented sharing of resources, and the advantages of pooling interests became more evident.

The past few decades have also seen a change in the concept of what constitutes a public responsibility toward the individual and the family. Until very recently, if a man lost his job, if an aged couple faced impoverished years, if a family lost its breadwinner, this was a private affair until the individual or the family became a public charge. Today, for the man deprived of employment, or retired in old-age, and for the family left widowed and orphaned, public insurance protection has begun to prevent catastrophe, dependency, and indignity. Fully as important to the welfare of the nation and of the individual as employment security or old-age and survivor's security is health security.

V

Health security for the individual means more than community provision of public health services; it also means access to needed personal health services at a cost which the family budget can bear. In a few countries of the world personal health services are provided wholly or largely as a tax-supported public service. It is assumed here that the more appropriate and acceptable way in the United States will be through the method of social insurance.

The goal of medical-care insurance should be protection for all or nearly all the population. Since the states have not entered this field, it has been proposed that a national system of prepayment for medical care become part of the national system of social insurance, and that its operation be primarily a function of the federal government. Decentralization of operation, including use of state and local levels of government in administration, is contemplated in the details of such a proposal.

As against such a plan, it is proposed by some that primary responsibility for insurance against medical costs should reside at the state rather than at the national level of government.

There are clear advantages for a national insurance system over the possibility of fifty-one separate state and territorial systems. If the initiative is left wholly to the states for the development of medical-care insurance plans, the same uneven developments that have characterized state health programs in the past may be expected to continue. Each state would have to rely on its own resources, thereby perpetuating the undesirable variations that now exist in public health services and in private medical personnel and facilities.

State medical-care insurance plans, assuming they could initially overcome their financial and other obstacles sufficiently to go into operation, would serve the purpose of stimulating a better distribution of personnel and a more adequate construction of facilities within individual states. But a national system is needed to encourage better distribution of personnel and facilities among the states. Individual state programs, requiring separate determination of eligibility, would entail large unnecessary administrative expenses, and would impede continuity of protection and ready access to services for persons who move

across state lines. There are several million migratory workers in the United States, and several million persons who work in one state, where they would presumably contribute under one system, and who live in a neighboring state, where they would want to avail themselves of medical benefits which would be given under another system. Under a national system, such difficulties would not arise. A national system, furthermore, would be freely able to use natural medical and hospital service areas, regardless of state lines.

Many states have considered the inauguration of medical-care insurance; none has done so. In addition to other difficulties, each state hesitates to place its economy and its business under a levy of taxes not also borne by the citizens or the business of other states. Public support for medical-care insurance has been especially lively in New York and California, two of the wealthiest states in the Union. Both considered it actively in the last year or two, but neither could solve the problems inherent in state-by-state action.

There are some who advocate a federal-state pattern as an alternative to either a national system or independent state action. Such a plan raises complex questions. If a federal-state program is to be without federal standards for the state systems (as to minimum or uniform coverage, and services), it would not lend itself to the use of insurance premiums as a source of the federal funds; since it would probably lead to state systems with variable coverage and benefits, it would require flexible federal grants-in-aid, financed out of general revenues. It would also invite or create competitive economic situations among states that would be avoided by a national system. Moreover, to the extent that some or many of the states failed to develop insurance systems, or developed systems much less adequate than could be established on a national basis, the federal government would have failed in meeting the obligations of its responsibilities for the nation's health.

If a federal-state pattern is to avoid many of these difficulties, and if insurance premiums are to finance part or all of the federal costs, there must be specific federal standards to be met by any state system that would qualify for federal insurance grants-in-aid or partial reimbursements. Such a program is feasible, but it should be considered with frank appreciation of the obligations that the states would be expected to assume under it—including a readiness to accept and observe the federal standards essential to the success of the whole system.

Upon these considerations—of both positive and negative nature—rests the proposal that prepayment of medical costs should be implemented through a national insurance system.

VI

Administration of a national insurance system is not restricted to the federal government; it can call upon governmental agencies at all levels to play appropriate roles.

The national agency, itself, will have both management and policy-making functions which cannot be delegated if the goals of a national program are to be achieved. With respect to management, there is an obvious economy and efficiency in having the collection of the insurance funds carried out by the federal agency, and insofar as possible in conjunction with the collection of contributions for the other parts of the national social insurance program. Moreover, if the coverage is less than national, the wage-records for old-age and survivors insurance—supplemented by additional earnings records if coverage for health insurance is broader—can be used in determining eligibility for medical-care benefits.

The general scope of the health services to be provided as insurance benefits will presumably be determined by statute. The national administration must carry responsibility for the general policy decisions and actions necessary to assure that the benefits are or become actually available to all insured persons. The insurance program would have to work with, and build upon, existing medical personnel and facilities. There is much which a national administration could do immediately to bring about the development of facilities where they are now most inadequate, and to encourage physicians, dentists, and nurses to settle in areas where they are most needed. The national administration could also undertake broad responsibility for promoting research, for disseminating new information among medical practitioners in all parts of the country, and for providing opportunities to all medical practitioners for continued training and education.

The principal operations of an insurance system to make medical, hospital, dental, nursing, laboratory, and other services available as benefits, would, of necessity, be implemented at the local level, in the communities where the medical practitioners and the insured persons live. Between the local community where the medical-care pro-

gram would function on a consumer basis and the national government where general policies would be determined there is a broad area of administration in which alternative patterns of development are possible.

In view of the importance of coordination among the several parts of a national health program, a pattern which has many advantages would be the use of the state governments as agents of the national government in the administration of the medical-care insurance system. Such an arrangement would facilitate and encourage a close coordination of the public health and special maternal and child health services with the personal health services provided under the insurance system. Whether the state and local agencies to be responsible for the over-all health program should be the existing health agencies or new agencies created for the specific purpose of administering that program might need to be answered differently in different places.

VII

The administration of a medical research and education program would lend itself either to wholly national operation or to partly national and partly state operation through federal grants.

A national health insurance system might well undertake to help finance opportunities for advanced study or periodic refresher courses for medical practitioners engaged in insurance practice.

On the other hand, it may be anticipated that medical research will be developed in large part through grants of funds to institutions, such as hospitals, clinics, universities, etc. For such purposes, it might be feasible for the states to operate parts of the over-all program with federal financial assistance.

The administration, as well as the scope and content, of a program of medical research and education—within the framework of a national health program—should, of course, be appropriately related to whatever more general program is developed for aid to scientific research by the federal government.

VIII

A national health program includes proposals to insure the wage or salary earner against loss of income because of disability. There is, I believe, widespread agreement that insurance against long-continued or permanent disability requires the kind of provision that we already have for the related risk of old-age retirement. A national system, with national administration by the federal government, is indicated.

In the case of social insurance against temporary disability three broad alternatives are open. Protection against this risk could be achieved by making it an integral part of the national system, by state action alone, or by joint action of the federal and state governments. Although two states (Rhode Island and California) have adopted systems of cash sickness insurance, a peculiar circumstance—the availability of employee contributions in unemployment insurance—which encouraged this action in these two instances does not obtain for many states. Extensive action by the states alone is not very likely in the near future. Joint federal-state programs, involving roles at both of these levels, could take various forms. National action would hold the largest promise for achieving adequate protection against this common risk.

IX

A national health program, comprehensive in its aims, would be intimately related to the lives of all our citizens. It invites the participation, not only of private practitioners and service facilities, but of existing governmental agencies at every level. In addition, it may need the services of new units of government. Coordination of effort and service must be the keynote of the administration of such a program to ensure maximum effectiveness.

Determining the role of each level of government and of each participating agency of government in the total structure should not, in spite of an apparent complexity of interrelationships, present insuperable difficulties. In our democracy, government has no separate existence in and of itself; it is an instrument for public service. Like all social institutions, it is resistant to change; but it is also responsive to change in public attitudes and policies, adjusting its structure to the requirements of its functions. If our society decides that it wants a national health program, it has at hand in its government an instrumentality to carry out the common will.

CONVALESCENCE AND REHABILITATION

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(*Read April 18, 1946, in the Symposium on Present Day Social and Economic Aspects of National Health*)

IT is paradoxical that war brings mankind certain benefits. That through a concerted effort to annihilate man we have learned more and better ways to preserve him is a sorry truth, but none the less true. The science of medicine has passed through many phases, and disasters of one sort or another have accounted for many of its advances.

One such disaster was World War II, and from it we have begun to learn, among other things, the importance of rehabilitation in the successful treatment of mental and physical diseases. This simply means that we have begun to deal with the influence of disease upon the individual in terms of its economic, vocational, social, and personal effects. In our search for new drugs, diagnostic procedures, surgical techniques and laboratory methods, we have too frequently overlooked the extra-physical results of illness—the changes it creates in the mind and in the habits of the patient as well as in his body.

The average patient during a hospital stay suffers 10 per cent of the time from pain and 90 per cent of the time from boredom. This is equally true of both civilian and military hospitals, though more devastating to the latter for there is less time to waste in war than in peace. The realization that wasted time could be converted into purposeful activity by a well-integrated rehabilitation program, with equal emphasis on physical reconditioning, psychological readjustment, and avocational training, led to the establishment of special convalescent hospitals by the Army Air Forces in 1943. These hospitals treated men, not diseases. Their purpose was to provide the combat-soldier with a laboratory of opportunity where he might regain not only health but the attitudes, habits, and values compatible with the normal behavior patterns that war had disrupted and distorted.

The hospital staff was enlarged to include not only medical specialists, but physical therapists, educators, athletic trainers, occupational therapists, social service workers, personal counselors, and vocational guidance experts who worked together as a team to treat the needs of the "whole man." The captain of the team was the personal physician or "family doctor" to whom each patient was assigned on entering the hospital, and to whom he could go with any problem, no matter what it was.

With the aid of this highly qualified and diversified hospital staff, a broad program of rehabilitation was put into operation with the result that the hospital was transformed into a combination schoolroom, gymnasium, machine shop, psychiatric clinic, vocational guidance center, and town hall.

Physical reconditioning was begun the moment the acute illness or surgery terminated, and, through a progressive and graduated program of calisthenics, active recreation, and competitive team play, patients were able to reach the peak of physical fitness during the convalescent period.

Classes and individual instruction were given in such subjects as administration, clerical training, electricity, canvas and leather work, radio operation and repair, welding, woodworking, and scores of other avocational and educational activities. In addition, on-the-job training was given to supplement didactic teaching. For the men who, because of disability, were to be separated from the service there was a complete program of vocational guidance based on achievement, aptitude, and functional testing and interests determined by a series of short work experiences. The patient learned not only what he liked to do but what he was able to do, both in terms of ability and in terms of any handicaps he had. This information was correlated by a skilled vocational counselor with the job opportunities in the field chosen, and the patient, upon discharge from the hospital, had a complete, objective, vocational profile and insight into his specific problem.

Such opportunities as these and many others were created by the operation of a rehabilitation program in Army Air Forces hospitals because the underlying philosophy of the Air Force was "to take care of its own." Can a democracy do

less? Can a nation at peace refuse or fail to perform those services for its citizens which the military performs for its soldiers? The answer is that it can and it does.

Both the medical profession and the general public are genuinely concerned with the problems which must be faced by thousands of disabled veterans as they return to their communities, but few of us realize that our disabled veterans constitute only a small part of the total number of handicapped and disabled in this country.

During the first four years of war there were approximately 17,000 amputations in the Army, but during this same period there were 120,000 major amputations from disease and accident in our civilian population. In 1940 the United States had some six and one-half million disabled males between the ages of fifteen and sixty-four years, men who normally would be income-producing. This six and one-half million, plus the number of disabled or handicapped veterans being discharged from our military hospitals, will give us, when demobilization is completed, approximately eight million working-age males who are disabled to the extent of requiring physical or vocational rehabilitation of special placement aids if they are to be successfully employed. This represents one person in sixteen in our general population and one in seven in our male working population. Each year this number is increased by the 350,000 persons who are permanently disabled by accident alone.

The armed forces and some outstanding community civilian agencies such as New York's Institute for the Crippled and Disabled have demonstrated that the physical and emotional rehabilitation of our handicapped is possible. It has been estimated that 97 per cent of these individuals can be rehabilitated to such an extent they can be gainfully employed.

During the war, because of the acute shortage of manpower, 83 per cent of our nation's industries employed handicapped workers, many of whom were thus given the first opportunity of their lives to take a place on the production line and prove that they could, with good selective placement, produce on par with normal workers. Reports from those industries revealed that among the handicapped there was a much smaller labor turnover, less absenteeism, fewer accidents, and equal or higher production rates. The theory long held by employers that increased accident rates resulted from the employment of impaired workers was finally disproved by surveys made in eighty-seven of the great industrial plants in America, including the Ford Motor Company River Rouge Plant with its 12,000 handicapped workers. These reports show that 56 per cent found the accident rate for the handicapped lower than that of the able-bodied; 42 per cent found the rate the same as for the able-bodied; and only 2 per cent found it to be higher. Selective placement, which means fitting the worker to the job rather than fitting the job to the worker, is the key to the utilization of impaired workers, and proper selective placement was the basis for their excellent record in wartime production.

Most individuals use less than 10 per cent of their potential efficiencies in normal pursuits. It is only in emergencies that we call upon our tremendous reserves of physical power and ability. In many cases a worker's physical defect acts as a tremendous stimulus to over-compensation, resulting in extraordinary physical ability. Adler developed a complete system of psychology on the basis of inferiority. He believed that the successful, the efficient, and the aggressive individual was one who was compensating for some inferiority. The employer of the handicapped workman can put that psychology into purposeful and gainful application.

A survey completed in a number of Westinghouse Electric Company plants disclosed that approximately 19 per cent of the occupations could be performed satisfactorily by persons having only one leg, 17 per cent by operators who must use crutches, 83 per cent by men with only one eye, and 82 per cent by the deaf.

Although much work still needs to be done in analyzing the physical requirements of jobs and physical capacities of workers, the United States Employment Service has developed adequate tools and techniques to meet the needs of the bulk of our handicapped population.

The Federal Office of Vocational Rehabilitation has reported how rehabilitation pays off economically. Of the 43,997 persons undergoing vocational rehabilitation under this agency in 1944, 22 per cent, or more than 10,000, had never been gainfully employed and nearly 90 per cent were not employed at the time they started their rehabilitation. The average annual wage of the entire group prior to rehabilitation was $148. After rehabilitation, the average annual wage of the group increased to $1,768. The total earnings of the entire group rose from $6,510,556 to $77,786,696.

Prior to rehabilitation the majority of these persons relied on general public assistance, not only for the disabled individual but also for his family. The annual cost of this assistance to the taxpayer was from $300 to $500 per case, but the total cost of their rehabilitation averaged only $300 per case, a non-recurring expenditure.

No degree of economic gain, however, can measure the social and moral satisfaction obtained by the successfully rehabilitated and employed handicapped worker and his family. Nor can it measure the value to society in the transformation of these individuals from dependents to productive, self-reliant individuals.

The handicapped citizens proved their worth during the war and were lauded by industry for their efforts. As production is cut back, however, industry drops large numbers from its payrolls. Demobilized veterans return from the war in increasingly large numbers, and more employees have to be released to make room for veterans who not only deserve jobs but are guaranteed them by law. Dismissals are on the basis of seniority and the disabled, being the last to be hired, are among the first to be dismissed.

Having enjoyed a brief period of economic prosperity, the handicapped worker suddenly finds that the labor market is loosening and that jobs for which he can qualify are no longer available. Greater production during the war allowed industry to break job structures into small components, but now as production is being curtailed the average worker, instead of doing one small highly specialized task, finds he must be able to do several. This demand for greater flexibility on the part of the worker further reduces the employment opportunities of the disabled. During the war the job was adapted to the worker; now the worker must be made to fit the job. The only answer lies in rehabilitating the worker.

The record of the federal-state rehabilitation programs under the Office of Vocational Rehabilitation has been heartening, but when it is compared to the one and one-half to two million persons who are in urgent need of such care it is woefully inadequate. The question usually raised is, "If the vocational rehabilitation program has been so successful with this small group, why aren't the remaining million and a half to two million given its advantages?"

The answer is that there simply aren't enough rehabilitation centers in the country to which these cases can be referred. The state and federal rehabilitation programs do not do the actual physical restoration and vocational retraining of these people. They supply the funds, help select a suitable vocation for which the person possesses both aptitude and physical abilities, and supervise his retraining. The actual work, however, is done by other agencies. These agencies may be public or private schools, trade schools, apprenticeship training courses, rehabilitation centers, hospitals, group clinics, or other medical facilities. Those who possess the necessary skilled personnel and facilities to do an adequate job of physical restoration and retraining to rehabilitate cases vocationally, are so few in number that opportunity is denied to the vast majority of our disabled population.

The funds and authority are available, but the facilities equipped for doing the actual job of rehabilitation are inadequate. Several national organizations are making efforts to stimulate public interest in rehabilitation by demonstrating to both the medical profession and the public what actually can be done by an integrated program of physical, mental, and social vocational adjustment.

One such group is the Baruch Committee on Physical Medicine which is translating the experience of the armed forces in rehabilitation into its civilian application, in order that this experience may be made available to the medical profession and those interested in community rehabilitation centers. They are blueprinting a model center, outlining its mission, organization, components, physical set-up, and its relationship to the medical and allied professions—industry, labor, social, and governmental agencies—and to the community as a whole. Adequate programs designed to take men from the bed back to the job will not only save the worker as a producing member of the community, but can save industry tremendous sums from compensation claims.

The success of the military services in the fields of rehabilitation and planned convalescence has demonstrated what can be done by planning and integrating medical care along with the ancillary sciences to provide treatment of the whole man in terms of his medical, social, vocational, economic and personal problems. A similarily comprehensive medical rehabilitation program is now underway in the Veterans Administration. It now remains for the nation to follow suit—to apply to its peace-time civilian institutions the lessons learned in war.

Hospitals can be made into institutions of opportunity as well as healing. The long monoton-

ous hours of convalescence which are wasted in hospital wards could be turned into periods of useful and productive activity which would aid the patient in his reorientation to normal living. Classes in dietetics, pre-natal care, home nursing, consumer buying, and household mechanics could make convalescence in the women's ward an interesting and profitable experience. Woodwork, photography, radio repair, and work with the new plastics could present both instructive and avocational opportunities to the men's group.

All types of literature on foreign affairs, democratic living, homemaking, avocations, and hobbies are readily available. Qualified volunteers can be obtained to do the teaching under the supervision of a small professional staff. Hundreds of interesting films are available for the asking. With such programs bodies and minds will heal more quickly.

Experience with physically and emotionally wounded soldiers has given us new knowledge and new tools in rehabilitation—the third phase of medical care that takes a man back to productivity. It is really a new medical speciality which is adequately described by an old medical term, "orthergasia," which literally means conditioning for normal function and adjustment—the goal of rehabilitation.

THE PLACE OF THE PHYSICIAN IN MODERN SOCIETY

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(Read April 18, 1946, in the Symposium on Present Day Social and Economic Aspects of National Health)

THE place that the physician holds in a given society is determined by a variety of factors of which the most important are: the social and economic structure of that society, the valuation of health and disease by that society, the tasks it sets to its physicians, and finally the technology of medicine available to the doctors in such a period. These factors have changed a great deal in the course of time and so has consequently the position of the physician. If we wish to obtain a clear picture of the place that the doctor occupies today, in our modern industrial society, the best we can do is give a brief analysis of developments so that we may see the physician against the background of history.

In primitive societies the sick man is an individual who is out of harmony with the forces of nature and of society. Disease is frequently considered a social sanction and the patient is the innocent or guilty victim of evil magic, of the wrath of spirits, or he is punished by the benevolent deity for an offense. The medicine man holds an extremely important position in primitive society and is infinitely more than the ancestor of the modern physician. He is actually the ancestor of all our professions, is priest, sorcerer, physician in one and very frequently the chief, the judge, and bard of the tribe.

In the Semitic civilizations of the ancient Orient the view had crystallized that disease, like suffering at large, is a punishment for sin, for a sin of the individual, of his parents or his clan. The patient atones by suffering, and where such a view prevails his position in society is burdened with an odium, the odium of sinfulness, a view that may still be encountered as a prejudice in our modern society, particularly in the attitude of certain groups toward mental and venereal diseases. In Babylonian and related societies the physician was a priest, as a rule, whose primary function it was to interpret omens so as to know the intentions of the gods, and to placate them when they had been provoked. The fact that he was a priest determined his position in society.

Conditions changed radically in ancient Greece, a world of the healthy and sound in which health was considered one of the highest goods and disease a great evil that made man inferior. It was considered senseless for the doctor to give his services to a hopeless patient since the goal, recovery, could never be reached. The best course to take with weak and crippled infants was to destroy them since they would never be able to become normal human beings. The Stoics endeavored to overcome these views by declaring health and disease *adiaphora,* matters of indifference. But in the course of time even they had to make concessions to the generally accepted views and they differentiated between desirable adiaphora, such as health and wealth, and undesirable ones like disease and poverty.

The Hippocratic physician was a craftsman like the shoemaker, the blacksmith, or the artist, and this determined his place in society. He was educated like other craftsmen by being apprenticed to a master whom he served for a number of years until he became a master himself. Most Hippocratic doctors practised their craft as itinerants, travelling from town to town, knocking at doors, offering their services, and, if there was enough work for them in a given place, they rented a shop, the *iatreion,* to which families brought their sick for examination and treatment. Only large cities had permanent physicians and, from the sixth century B.C. on, municipalities tried to attract a physician by offering him a salary that was raised through taxation. But the majority of all physicians practised as itinerant craftsmen selling their services on the open market to whoever could afford the price. People who could not purchase medical care had no attention, a condition that was generally accepted. As the Hippocratic physician worked for money, his social position was not very high in a society that despised the earning of money. Yet among the craftsmen the doctor was one of the most highly esteemed because health was greatly valued.

Again a radical change was effected with the advent of Christianity that came into the world as the joyful gospel that promised healing and re-

demption. The world was sick and in need of help and the new religion promised healing, both spiritual healing and physical restoration. Had not Christ himself performed many cures? Christianity was in competition with the ancient healing cults and won out ultimately because it was not a religion that addressed itself only to the pure and righteous but had a strong appeal to the sick, the sinner, to the slaves, and all the downtrodden. In Christian society the sick man was no longer burdened with the odium of sinfulness or inferiority; he was, on the contrary, given a preferential position and it was declared the duty of the community to help and attend the sick and the poor. Whoever joined the Christian community became the member of a family with all the rights and duties of such.

The physician of the early Middle Ages was a cleric, as a rule, and was thus economically independent of his patients so that he could practise medicine as a divine mission or as a charitable service. In the later Middle Ages when an increasing number of laymen entered the profession, many of them still remained economically independent, having salaried positions in the service of municipalities or as physicians-in-ordinary to a nobleman, lay or ecclesiastical. But even those who were engaged in what we would call private practice were bound by the rigid regulations of the medical faculties that exercised very much the same control over the physicians as the guilds did over the craftsmen, transmitting an accepted body of knowledge and skills, setting standards, and eliminating competition by prescribing the physician's actions, determining fees and similar measures. The Middle Ages had a well-integrated system of medical care. The view was generally accepted that everybody whether rich or poor, high or low should have all the medical services he needed, and the physician was in a position that permitted him to give his services to all without economic barriers. He was a scholar trained in the universities and was greatly respected.

Conditions changed again when in the sixteenth century a new economic order developed that appealed to the individual in man and called for free competition and free initiative. The traditional authorities were fought. The highest authority, the church, was reformed. The power of the guilds was broken, and, since the medical faculties of the universities remained mediaeval in character, academies were founded where the new science was cultivated. Medical colleges were established in several countries that granted the license to practise, a privilege that had been reserved for the universities in the past. Professions were no longer divine missions but became in increasing measure the means of making a living. The day came when the physician found himself in a competitive world that was very foreign to his traditions, in a society that was still upholding the view that medical care should be available to all, a society, however, in which he, the scholar, was supposed to sell his services as the Hippocratic craftsman had done, in order to make a living. For many centuries the physicians did their best to escape from the necessities of this new competitive world. The ambition of a doctor in the seventeenth, eighteenth, and in many countries far into the nineteenth century, was to have a salaried position in the service of cities or as body physician. With the rise of the middle class, doctors became physicians-in-ordinary to a number of middle class families who at the end of the year paid him an amount of money that was considered fair and that they could afford. The family doctor is the democratic form of the court physician and a product of the emancipation of the middle class. In spite of all efforts to resist economic developments and to evade them whenever possible, preserving mediaeval traditions in a rapidly changing world, the doctor could not prevent being engulfed in a world that was ruled by iron economic necessities. And all he could do then was to organize medical societies that promulgated codes of ethics and etiquettes, the purpose of which was to protect the profession from some of the worst abuses of competitive business.

Against this background of history we may attempt to define the place that the physician holds in our modern industrial society. First of all, we realize that health is valued very highly today. We are convinced that a modern democratic society cannot function unless its members are educated, and we therefore make education available to all the people as a public service. Similarly we believe that society cannot function unless its members are in good health. The sick individual drops out of society, so to say, becomes unemployed and may even become unemployable if a permanent disability results from his illness. Our tendency therefore must be to provide complete health services to all the people irrespective of race, creed, economic status and irrespective of whether people live in town or country. The old mediaeval view that the community has a re-

sponsibility toward its members is still fully alive. It was originally motivated by charity, became humanitarianism in the eighteenth century, and in the nineteenth century there was a good deal of sound utilitarianism involved. It was realized very justly that sick groups of the population are a menace and a burden to all.

Gradually the view crystallized that the member of a modern state may claim a right to health or rather, since health cannot be guaranteed, a right to have all means for the protection and restoration of health made available to him. This view was clearly formulated a hundred years ago when a great medical reform movement swept over Europe. A German, S. Neumann, in 1847 in a book entitled *The Public Health and Property* pointed out that the state had as one of its purposes the protection of the people's property, that the majority of people, however, had only one possession, their labor power, one which was entirely determined by their health. He therefore concluded that the state had the duty to protect the people's health as their most valuable property. If the purpose of the state is to promote the general welfare of the people, then there can be no doubt that the protection of health must be one of the primary concerns of government.

When we look at the task that modern society has placed in the hands of its physician, we soon find that the scope of medicine has broadened tremendously. From a private relationship between two individuals, medicine is rapidly becoming a social institution. It is one link in a great chain of social welfare institutions. Medicine, usually regarded as a natural science, actually is a *social science* because its goal is social. Its primary target must be to keep individuals adjusted to their environment as useful members of society, or to re-adjust them when they have dropped out as a result of illness. In combating disease the physician uses methods of the natural sciences every day, but to a social end.

For thousands of years the treatment of the sick was considered the primary task of medicine while today its scope is infinitely broader. Society has given the physician four major tasks, which, although they can hardly be separated since there are no sharp borderlines, yet may be discussed separately for simplicity's sake. The first task, and one of the most important today, is the *promotion of health*. Health cannot be taken for granted. It must be maintained and promoted through incessant activities in which the physician shares with a great many other workers. Education, general education and health education, represent the starting point of all health activities, and the school undoubtedly is one of the most important public health institutions. Health is promoted furthermore by our developing a program of physical culture that must reach all groups of the population and all age groups. Physical education does not consist of competitive and commercialized athletics but is primarily an attitude toward health, the creation and satisfaction of a need for organized physical exercise that will benefit the general condition of an individual's health. Another important field in the promotion of health and one in which we still lag behind is the provision of means of rest and recreation. Labor power spent in the process of production must be restored. Periods of work must be followed by periods of rest, and this rest should in certain cases be under medical supervision. In handling our automobiles we have learned that it is cheaper to have them overhauled periodically and to have minor repairs made before the car breaks down. A program of human conservation would make use of the same principle. The promotion of health moreover requires the provision of a decent standard of living with the best possible living and labor conditions. The promotion of the people's health is undoubtedly an eminently social task that calls for the coordinated efforts of large groups, of the statesman, labor, industry, of the educator, and of the physician who, as an expert in matters of health, must define norms and set standards.

By promoting health society prevents illness, yet special measures of *prevention* are needed to protect society against communicable diseases through the sanitation of dwelling places, quarantine, immunizations, the finding, segregation, and treatment of individuals who, suffering from communicable diseases, are a menace to their fellow man. These are the classical tasks of the public health services which in all countries had a great development during the past hundred years. These are tasks of such magnitude that they cannot be carried out without the state power. Thus an extremely important medical function has become part of the administration of the state and the physician functions in it as a civil servant.

The effective prevention of illness, however, requires in addition special organizations and services for the protection of those groups of the population that are particularly threatened either physiologically or socially. Especially menaced for physiological reasons are women in pregnancy, childbirth, and childbed, are infants, young chil-

dren, and aged people. Socially threatened as a result of their occupation are industrial workers. Society, therefore, called upon the doctor to develop special methods and institutions for the protection of mother and child, for the care of the aged, and for the protection of labor. This, however, also requires group activities and is thus an eminently social function.

When the promotion of health and the prevention of disease have broken down and an individual has fallen ill, then the physician's immediate task is the *restoration of the patient's health.* Uncomplicated as the relationship between physician and patient may appear, yet it also includes strong social elements. In taking the history of a patient, the physician endeavors to obtain a picture of his living and working conditions, of his relationships to the family and other social groups because the illness may have been caused directly or indirectly by a wrong mode of living or by social maladjustment. The doctor is an individual, to be sure, but is at the same time also a member of society who, in the patient, treats another individual who is also a member of a group. Treatment may consist in the correction of a social relationship.

From all that has been said, it is apparent that the physical restoration of a patient cannot be the final goal of the physician's actions. No task may be considered completed *before the patient has been rehabilitated,* reintegrated into society as a useful member. A highly specialized and technical society such as ours has jobs for every degree of intelligence and physical capacity. Even the most disabled individuals, blind men, people who have lost extremities, and other invalids can perform socially useful and therefore necessary work that deserves to be fully remunerated. Work is one of the most powerful factors of health, and society should make every possible effort to prevent skilled workers from dropping into the ranks of the unskilled laborers as a result of physical disability. With our present advanced technology, people with every degree of disability can be retrained in such a way that they will be able to fulfill useful work that will permit them to maintain their self respect as well as their economic status. In times of war, society is more strongly aware of its responsibility toward the men who sacrificed their health for its protection, and a great deal of rehabilitation work is performed very successfully with war veterans. The battle against disease and its dire consequences, however, is one that knows no armistice, and we therefore must provide training centers for the rehabilitation of civilians also. The Soviet Union has set a great example to the world in demonstrating how physically handicapped individuals can perform highly skilled work in factories. Under a system of free competition, in periods of economic crises, it may be difficult to provide work for the disabled but if private industries cannot provide the necessary work government projects will have to do it.

Thus the scope of medicine has indeed broadened considerably and nobody will deny that the physician is playing an increasingly important part in society. His services are called upon by a great many other groups. He has become the adviser to the educator, and mental hygiene, in its beginnings yet, may prove to be a powerful method of preventing maladjustments in growing individuals and may thus be able to prevent not only disease but also crime. The physician is furthermore adviser to the court. The administration of justice would be impossible without his services. As scientific expert, he must determine the cause of death and the circumstances under which death occurred. As psychological adviser to the court, he must determine the responsibility of an individual under indictment, and more and more frequently is he consulted in determining whether a sentence is apt not only to punish but to rehabilitate a criminal and to readjust him to society.

Since poverty is still the major cause of illness in every country and the general standard of living is perhaps the most influential factor of health, the doctor's advice is requested by the statesman in problems of housing, nutrition, and an infinity of other questions where he has to establish the norms and standards that are conducive to health.

When we now look at the modern technology of medicine, we realize that tremendous changes have occurred particularly during the last hundred years as a result of the great development of science. Until a century ago the technology was very simple. The content of medicine could be assimilated in a few years of study. Methods of examination were uncomplicated and required only few instruments such as the stethoscope. Even the fever thermometer was not in general use at that time. Treatments were mostly empirical, and surgery was limited to the treatment of wounds, of fractures and dislocations, and to a relatively small number of classical operations.

From the middle of the nineteenth century on, and still more during the last fifty years, medicine has become very scientific, very technical, highly specialized, and very effective. And at the same

time the cost of production of the service increased considerably, much more rapidly than the purchasing power of the population. The general practitioner today needs the help and advice of a large number of specialists and of auxiliary personnel, technicians trained in chemistry, physiology, bacteriology, serology, physical therapists, and others. He needs the full resources of the medical center, the hospital, and laboratory. Hence, the present technology urgently requires teamwork, the cooperative efforts of groups of medical workers. Medicine is becoming group medicine that will be practised in medical centers; and in modern society a family is entitled to have not only a family doctor but its family medical center.

The same basic force that was responsible for the changed technology of medicine, namely, the rise of modern science, also effected basic changes in the structure of society. The development of science led to the great development in technology, as a result of which the world became industrialized. And today after two great industrial revolutions the overwhelming majority of all the gainfully employed individuals in an industrial society are wage-earners. In other words, a new medical science with broadened tasks is called upon to serve a new type of society and this obviously calls for adjustments, for a system that will permit the physician to make full use of the new technology and to practise preventive medicine on a large scale. For over five thousand years individuals fell sick before they saw a physician. The time has come for the physician to see the people before they are sick and to advise them on how to maintain their health. Another factor that determines the place of the physician in modern society is to be found in the increasing tendency on the part of society to liberate the physician from economic bonds, from the necessity to sell his services on the open market, a necessity that prevents him from settling where he is needed most, in poor districts, and forces him to practise where the per capita income of the population is large enough to provide him with an adequate income.

The desire to finance medical service in a more systematic way and to guarantee health services to all the people led to the development of Zemstvo medicine in Russia in 1864, and health insurance in Germany in 1883. Both systems endeavored to spread the unpredictable financial risk of illness among large groups of people and to pool their resources. Zemstvo medicine was a system of public medical services for the rural population of Russia, financed through taxation and administered locally by the district and provincial assemblies. It was the logical solution for a country where the majority of the population of low income was agricultural, while health insurance was at that time considered the more appropriate method of financing services in a country where industrial workers constituted the great majority of the people with low incomes. Under both systems attempts were made to create a place for the physician that made him independent of the ill health of the people and guaranteed him the standard of living to which he was entitled.

And so we are beginning to see the place that the physician is holding in modern society. We see him as a scientist, educator, and social worker ready to cooperate in teamwork, in close touch with the people he disinterestedly serves, a friend and leader who directs all his efforts toward the promotion of health and prevention of disease and becomes a therapist when his previous efforts have broken down—the social physician protecting the people and guiding them to a healthier and happier life.

THE RELATIONSHIPS BETWEEN GOVERNMENTAL AND PRIVATE RESPONSIBILITIES FOR NATIONAL HEALTH

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(*Read April 18, 1946, in the Symposium on Present Day Social and Economic Aspects of National Health*)

By the very nature of things there can be no precise and final division between governmental and private responsibilities for national health. These relationships are different now from what they were five, ten, or one hundred years ago. In like manner, the relationships of today will change in the future. At any time, the relationships between governmental and private responsibilities in this field will depend on many things. These relationships have changed with the level of development of medical science. They have changed with the increasing concentration of population in cities and towns. They have changed with the changing political and social temper of the nation.

In recent years there have been, along with these changing relationships, remarkable advances in the science of medicine. These advances have been possible because there existed a spirit of initiative and freedom for experimentation. There is constant danger that, as governmental responsibilities are extended, inflexible patterns will be established, either by law or regulation, which will dampen the spirit of initiative and handicap experimentation. Consequently, whatever changes in the relationships between governmental and private responsibilities may be made in the future, it is of the utmost importance that we preserve these characteristics of the system of private enterprise.

It is clear that government has primary responsibility with respect to certain activities essential to the health of the nation which, if they are to be performed effectively, must be handled by concerted action on the part of the community. On the other hand, the health and well being of the individual is affected by a multitude of decisions and actions which are, and must necessarily be, the responsibility of the individual. Since the health of the nation must be measured in terms of the health of its individual citizens, many of the essentials of national health must remain in the domain of private responsibilities.

However, the responsibility for many things which are essential to national health is divided between governmental agencies on the one hand and individuals and non-governmental organizations on the other. With respect to these activities government establishes a framework by setting standards, imposing restrictions, or establishing obligations, and within this framework the individual or the non-governmental organization shares in the responsibility. This type of joint responsibility is well illustrated by the manufacture of drugs and the processing of foods complying with the standards of the pure food and drug act.

It is primarily in this field of joint responsibilities that there is disagreement as to the proper nature and extent of governmental participation. Specifically, there is sharp disagreement with respect to the nature of the responsibility which government should assume for the provision of medical, hospital, and dental care for the self-supporting citizen and the extent to which government should assume responsibility for the continuation of the worker's income during periods of disability. It would be presumptuous of me to suggest that I have the capacity to discuss adequately the many separate problems existing in this field of controversy. Such a discussion would in any event require much more time than is available to me today.

The point of view of any individual with respect to such a controversial subject as this is bound to be colored by his background, his training, and his responsibilities. My approach to this subject is influenced by my actuarial training in balancing revenues with probable costs and by my experience with the practical administration of insurance contracts providing sickness and disability benefits. I make no apology for this emphasis upon practical administrative problems and the necessity of balancing revenues with costs. On the contrary, I believe that the critical analysis of the subject before us, with emphasis on practical administrative problems, is essential to the development of sound public policy.

Let us consider first the proposals for governmental action in the field of medical care. (I shall use the term "medical care" in it broadest sense so as to include hospital care and care by doctors, dentists, and other practitioners.)

What do the proponents of compulsory health insurance seek to accomplish in this field of medical care? Their objectives seem to be concerned with the kind and the quality of medical care which the American public is now getting as well as with the cost of this medical care. With respect to the kind and the quality of medical care it is claimed that not enough emphasis is placed on preventive care, that we do not have adequate facilities and personnel available for good medical care for all of the people, and that the facilities and personnel which we now have are not ideally distributed nor efficiently utilized. As to cost, it is claimed that good medical care is beyond the financial capacity of the majority of our citizens and that in any event these costs, because of their unpredictable incidence, frequently constitute financial catastrophes to the individuals who must pay the bills.

Much of this is true. The important question is will the proposals for compulsory health insurance, such as those contained in the Wagner-Murray-Dingell Bill, improve the situation? Many serious students of these problems have grave doubts on this point. Important among the reasons for these doubts are the following:

In the first place it is certain that many controls would be necessary both as to the manner in which the medical practitioners could practise their professions and as to the conditions under which eligible persons could avail themselves of medical services. These controls would probably be of such far-reaching character that they would result in unforeseen changes in the present bases of the practise of medicine. There has not been sufficient discussion of the necessity, under a plan of compulsory health insurance, for such controls, nor has adequate consideration been given to their probable consequences. While the proponents of compulsory health insurance have apparently given some consideration to these problems, they have not been frank with regard to these points with either the medical profession or the public.

As a result it is doubtful whether members of the medical profession would willingly participate in a plan of compulsory health insurance in sufficient numbers to enable it to achieve its objectives. Even if all of the present members of the medical profession should participate in and fully cooperate with the plan there are not enough doctors, dentists, and nurses available to give the public the quality of care which it is entitled to expect and at the same time to furnish the amount of care which would be demanded if the factor of private financial responsibility were entirely removed.

Let me elaborate on these points. At the same time, in order to give substance to my remarks, let me be specific in my references. President Truman and the Social Security Board have recommended that the Social Security Act be amended to include provision for medical care benefits. Senators Wagner and Murray, together with Representative Dingell, have, with the obvious approval of both the President and the Social Security Board, submitted to Congress a bill which would, among other things, provide such benefits. The remarks which follow will be based on the provisions of Title II of this bill relating to "prepaid personal health service benefits."

Substantially the entire population of this country including both employees and their dependents would, under the terms of this bill, be entitled to medical, dental, nursing, laboratory, and hospitalization benefits, subject to certain limitations. The cost of these benefits would, presumably, be met by a payroll tax upon both employers and employees. Responsibility for administration of this plan would be placed in the hands of the Surgeon General under the supervision and direction of the Federal Security Administrator. Provision is made for the establishment of an Advisory Council, appointed by the Surgeon General with the approval of the Federal Security Administrator. As its title indicates, the powers of this Council would be purely advisory.

The bill contains little specific detail as to administrative rules. Responsibility with accompanying broad authority would be vested in the Surgeon General to carry out the purposes of the bill in accordance with certain broad policies outlined in it. Because of the generality of these policies and the wide range of discretion given to these officials it is not possible to conclude from the bill alone what changes in the present system of medicine probably would result if this proposal became law.

It is, however, certain that a national health program such as proposed would cost a great deal of money. It is suggested that this cost would not be materially greater than the price now being paid by the American people for health care. Whether or not this is true the Surgeon General

would have to keep the cost of the program within the limitations imposed by the revenues available. If abuses developed, abuses which cost money and threatened the solvency of the program, the Surgeon General would be forced to take steps to cure those abuses, or to limit their financial effect. Whether he seeks to cure the abuses by regulations limiting the conditions under which an individual can obtain medical service or regulations restricting or prohibiting certain medical practices, or whether he seeks to limit the financial effect of abuses by changing the basis of compensation of physicians and dentists, these regulations can, and probably would, fundamentally alter many features of the present system of medicine and medical economics.

The avowed purpose of the bill is to give everyone ready access to good medical care. The Surgeon General must, therefore, obtain the participation and the cooperation of the medical professions. Without that participation and cooperation, including that of the more competent members of these professions, the plan would be an empty gesture. Whatever the justification for their attitude, the violent reaction of the organizations representing the major portion of the medical professions would indicate that such cooperation cannot be achieved at this time. Nor does it seem likely that their cooperation can be obtained in the future if there is a continuation of the lack of candor which has so far characterized the proponents of this type of legislation. The sort of cooperation which is necessary cannot be obtained by compulsion. If there is a reasonable basis for cooperation, obviously it can be best attained by a full and frank exploration of the necessary readjustments in the present system of medical care with such exploration being made jointly by the advocates of such legislation and representatives of the moderate and conservative elements of the medical professions.

As I have already stated, there are not now enough doctors, dentists, nurses, and hospitals in this country to give all of the medical, dental, and hospital care which would be demanded by the public if such care were made available without charge as the services are rendered.

Therefore if the purposes of the bill are to be carried out more hospitals must be constructed and more doctors, dentists, nurses, and technicians must be trained. President Truman has recommended financial assistance to the various states for the construction of more hospitals, and legislative proposals for this purpose are being given favorable consideration by Congress. But, as the President pointed out, the building of additional facilities will not provide service. Service can be provided only by competent, well trained personnel. The training of such personnel will take both money and time. But, most important, it will take an adequate supply of competent young people willing to enter these professions. The effectiveness of any program to train more medical personnel will be affected by the attractiveness of these professions to the young people of our country from whom future doctors, dentists, and nurses must be recruited.

Because it affects the attitude of the present members of these professions and the attitude of the potential future members, a most vital part of the program is the basis upon which those who render the service required under it will be compensated. The bill provides that the basis of compensation for general practitioners and dentists shall be determined by the majority of such practitioners in each local area with the right reserved to the Surgeon General to use a different basis of compensation for those who do not elect with the majority. It is well known that the majority of physicians in private practise today wish to continue the traditional fee-for-service basis of compensation for their services. It is with respect to this point particularly that the proponents of compulsory health insurance have lacked candor in dealing with the medical profession. While the bill provides that the doctors of any area may elect to continue to be paid on a fee-for-service basis, the principal proponents of this type of legislation, in a statement entitled "Principles of a Nation-Wide Health Program" published in November 1944, stated that:

> The fee-for-service method is most open to abuse by patients and physicians and is the most costly to administer. Adequate control of the services requires fiscal and professional supervision, which is expensive and often vexatious. The promotion of quality and of prevention is difficult. The use of the fee-for-service method should therefore be discouraged, except for specialist services under certain conditions.

I do not quarrel with the conclusion that compulsory health insurance and the fee-for-service method of paying the doctor for his services are incompatible. Such a conclusion is supported by the experience under the medical care plan recently adopted in New Zealand. In this plan, under which physicians are being paid for their services on a fee-for-service basis, substantial abuses are developing.

What would be the result, then, if the Surgeon General must permit the doctors of each local area to choose a method of compensation which experts in the field agree will not work, and it appears that a majority of doctors will choose that method? One of the first steps might be to reduce the rate of payment for each unit of service so as to bring the over-all cost of services within the available funds. To reduce the pay of conscientious and competent physicians because of abuses by patients and by less conscientious physicians would be intolerable. The conscientious doctor, if he is to receive the compensation to which he is entitled, would be forced to make unnecessary visits and adopt many other undesirable practices followed by the physician who has abused the system. There would result an application of Gresham's law to the field of medical practises, with the bad driving out the good.

The next step might well be the abandonment of the fee-for-service method as a basis of payment to the general practitioner. The alternative bases of compensation contemplated by the bill are payment to the general practitioner of a stipulated amount each year for each of his patients, the so-called capitation basis, or payment for the physician's services on a salary basis. These are, by and large, methods untried in this country in the field of general medical care. What effect they would have on the quality of medical care, its cost, and the attractiveness of the field of medicine to the present and the potential future doctors, dentists, and nurses is practically unknown.

It might be observed, however, that the capitation method, under which the physician is paid the same amount each year regardless of the work he performs, opens at least two avenues for substantial abuse. In the first place it would be to the financial advantage of the individual physician to avoid taking patients who are apt to require a substantial amount of medical care. There are many ways in which the physician could select his patients for this purpose, and apparently he would be free to do so since the bill would permit the physician to reject individual patients. In the second place the general practitioner would find himself able to handle more patients, and hence to increase his income, if he made a habit of referring patients to specialists as soon as some minor complication arose. Other serious abuses are possible. Whether these abuses would become realities, or would prove to be purely imaginary, can more properly be determined by experimentation with voluntary plans rather than by adoption of a nation-wide compulsory plan.

What would be the result if a salary basis of compensating physicians were substituted for our present fee-for-service basis? Would professional standards be higher or lower than at present? Would the net change in the picture, including the introduction of political and bureaucratic forces, make the medical professions more or less attractive to qualified potential entrants into these professions? The recent disclosures concerning the medical care provided through the Veterans Administration are disquieting in this connection. Certainly a careful examination of the character and quality of the services which are now being supplied by physicians employed on a salary basis, including an investigation of the reasons for any shortcomings in the quality of that service, should be made before serious consideration is given to the adoption of a national system which may force this as a general basis of compensation of physicians.

We have considered briefly the steps which might be taken for the purpose of limiting the financial effect of abuses by changes in the method of compensating physicians and other practitioners. Instead of attempting to limit the financial effect of abuses, the Surgeon General might attempt to avoid abuses by limiting the conditions under which an individual could avail himself of the services of a physician, dentist, or hospital, or by restricting or prohibiting certain types of practises by physicians, dentists, and hospitals.

Let us take a simple case by way of illustration. The Surgeon General might find that some physicians being reimbursed on a fee-for-service basis were making four, five, or six visits for treatment of common colds where one visit would have been sufficient. In order to reduce the financial burden of this type of abuse he might decide that in any case diagnosed as a common cold the physician would not be allowed payment for more than two visits without specific approval of the case by a medical administrative officer. Obviously, it would be a simple matter to circumvent such a restriction by changing the diagnosis. Consequently, if the necessity for such restrictions and regulations should arise in practise, the variety of diseases and the diversity of medical practises would inevitably lead to a formidable volume of rules, regulations, and report forms. Serious consideration should be given to the effect of such procedural problems on the ability of the physician to practise medicine efficiently and effectively.

The controls over the individual physician paid on a fee-for-service basis would arise from the necessity of the Surgeon General to limit costs. Use of a capitation basis or a salary basis has been suggested in order to avoid the problems of the fee-for-service basis. While these bases of compensation would be effective in limiting costs it is not clear that they would be effective in maintaining quality of medical care. Consequently, the controls which would be required under a salary basis or a capitation basis would probably be concerned with the problem of trying to assure a high quality of care, and would probably do so by detailed regulations as to the precise manner in which the physician should practise medicine. Such a development would be accompanied by the grave danger that, by placing an administrative stamp of approval on currently accepted methods of treatment, new techniques and methods of treatment would be difficult to adopt, and might, in fact, be strangled by administrative red tape.

In addition to attempting to control abuses by adopting new methods of compensation, or by regulating the methods of practise by physicians, dentists, and hospitals, the Surgeon General might have to limit the services which would be available under the proposed system. Such limitations are specifically contemplated by the Wagner-Murray-Dingell Bill. For instance it is obviously impossible for available personnel to furnish complete dental services to the entire population. Accordingly, the Surgeon General would be permitted to restrict the dental services to examination, diagnosis, prophylaxis, extraction, and treatment of acute diseases of the teeth. Home nursing service and laboratory benefits might likewise be limited because of restricted personnel and in order to control costs. In addition the Surgeon General would be authorized to require the payment of a fee with respect to the first service from a physician, dentist, or nurse, or with respect to each service in a period of sickness or course of treatment. The amount of the fee is to be "at an amount estimated to be sufficient to prevent or reduce abuses and not such as to interpose a substantial financial restraint against proper and needed receipt of medical, dental or home nursing benefit."

The rate of payment for hospital services would be fixed by the Surgeon General somewhere between $3.00 and $7.00 a day for the first thirty days in a period of hospitalization and between $1.50 and $4.50 a day for the balance of the period. The maximum period of benefit would also be subject to determination by the Surgeon General, but would be required, by the terms of the bill, to be at least sixty days.

This hospital benefit, if fixed anywhere near the lower limits permitted, would not be enough to pay the average charges for ward care. This benefit would be substantially less adequate than that provided to the twenty-nine million people now protected under Blue Cross plans and group hospital expense insurance plans. Moreover, the introduction of such an inadequate benefit on a nation-wide compulsory basis probably would be substantially a death blow to these voluntary plans of protection. The phenomenal growth in popularity of voluntary hospital expense insurance has been due, in large part, to the relatively low cost and to the dramatic character of the contingency insured. The advent of compulsory insurance, even though inadequate, would probably result in a feeling of complacence which would make the sale of supplemental coverage difficult. This fact, together with the increased overhead of handling such insurance, would tend to force discontinuance of such plans and thereby make it practically impossible for most people to get adequate protection against the high costs of hospital care.

In passing it should be noted that far-reaching effects upon the whole system of administration of hospitals and upon the practise of medicine in hospitals would result if, by means of such a plan, the volume of ward care were greatly increased at the expense of private and semi-private care.

One of the main objectives of those who propose compulsory health insurance is to obtain greater emphasis on preventive medical care. The Wagner-Murray-Dingell Bill recognizes, however, that sheer lack of available personnel, coupled with possible lack of funds, will limit that emphasis, and that abuses may arise which will necessitate barriers to such care. If our available personnel is limited, is it not possible that the abuses which will develop will divert the time and talents of that personnel to such an extent that less rather than more emphasis will be put on preventive care?

This suggests the thought that more progress in improving preventive medical care could be made by further emphasizing medical research, by improving facilities for medical education, and by expanding and improving our public health services than would result from adoption of such a far-reaching and apparently unworkable plan as

that contained in the Wagner-Murray-Dingell Bill.

So much for compulsory medical care benefits. Let us turn now to the question of cash benefits during temporary disability.

In many respects the continuation of a part of the wage earner's income during disability is as important to his health and well being as is the provision of good medical care. The wage earner must buy food and clothing and provide a roof over his head during illness as well as in health. So it is not illogical for the proponent of compulsory health insurance to include as a corollary to compulsory medical care benefits provision for cash benefits during disability as an integral part of his proposal.

While such benefits were proposed by President Truman in his national health program message to Congress, and were again proposed by the Social Security Board in its tenth annual report, no provision for such benefits is included in the edition of the Wagner-Murray-Dingell Bill introduced in Congress last November. However, a pattern for such proposals has been set by many previous bills on the subject which have been introduced in Congress, including several bills introduced by Senator Wagner, as well as by bills which have been introduced in the various state legislatures. Again, with respect to these proposals, there are fundamental questions as to the proper relationship between governmental and private responsibilities.

The typical proposal for compulsory temporary disability benefits is one which seeks, by setting up a monopolistic state insurance fund, to furnish benefits in the event of disability due to non-occupational accidents or illnesses at the same weekly rates, and for the same maximum amounts, as provided for unemployment compensation benefits. The weekly rates of benefit, and the maximum amounts of benefit, are determined on the basis of the employee's wages during a twelve month period, called a base period, which, in the average case, has ended nine months prior to the commencement of the period of disability with respect to which benefits are to be paid.

A plan of this character was adopted by the State of Rhode Island in 1942, with benefit payments commencing in 1943. The operation of this plan has furnished an interesting experiment in the feasibility of this type of legislation. Certain defects in the law have become apparent and attempts, so far unsuccessful, have been made to cure some of them by legislation. Other defects which have developed appear to be inherent in this type of plan. I will refer to these defects later.

There are many of us who believe that the establishment of a compulsory monopolistic plan of this character is an undesirable extension of the field of governmental operations into a field which can be, and has been, successfully operated by private enterprise. However, the mere statement of this belief serves to convince only those who already share it. Let me analyze some of the reasons which give rise to this belief.

A benefit during temporary disability is for the purpose of replacing a part of the income lost during disability and therefore grows directly out of the employment relationship. It is, in effect, a spreading of compensation for work performed and it may be provided by continuation of wages or salary during disability, or it may be provided by means of a mutual benefit association or through a labor union or by means of group insurance. In the great majority of cases the employee expects to, and does, return to work for the same employer upon recovery.

The primary defect of a monopolistic, governmental plan for temporary disability benefits is that it omits from responsibility for supervision and administration of the plan the one party who, by the very nature of the employment relationship, is best equipped to guard the plan against abuse. The fact is that it is relatively easy to feign disability or to prolong unduly a period of convalescence. When the disability benefit payments come from an institution, such as the state or federal government, which is far removed from the employee, and the amount of benefit claimed seems trivial in comparison with the apparently unlimited ability of the government to pay, the tendency for petty frauds and abuses grows. Unfortunately, once it becomes known that some are getting away with abuses, it becomes popular to follow suit.

Just how this works out in practise is well illustrated by the experience under the Rhode Island plan. Quite the reverse of the usual pattern of incidence of illness, the claim rate under the Rhode Island plan is highest during the summer months and lowest during the winter months. In 1944 the payments during the month of June, the month of highest payments during the year, were over 200 per cent of the payments in January. The payments in the summer months of June, July, and August, when real sickness is actually at its low point, accounted for payments 70 per cent greater than the payments in the months of January, February, and March, the months during

which real sickness rates are highest. This correlation between the high point in sick benefit payments and the best vacation weather can scarcely be pure coincidence.

The only way to control such abuses is to place responsibility for the administration of claims with some one who can and will protect the plan of disability benefits from illegitimate claims. The employer is ideally situated to exercise this responsibility. He is immediately aware of a potential claim for benefits when an employee fails to report for work. In most cases the employee will immediately get in touch with the employer and report sick. The employer can have a fellow employee, or a visiting nurse, or even a doctor visit the employee, depending on the conditions in the individual case. Certainly he wants the employee to come back to work but he wants a well employee back not a sick one, for a sick or a half-well employee is a liability on his hands. So while the employer is trying to get the employee back on the job, he is accomplishing several things. He is encouraging the employee to take all necessary steps to get well. He is, in a small way, increasing the productive capacity of the nation for a sick man, or a man who is feigning sickness, diminishes to that extent the total ability of the nation to produce. He is protecting the disability benefit plan against improper claims. And he is building up an atmosphere of financial responsibility for the plan which tends to discourage petty chiseling.

Not only does a monopolistic state plan tend to produce financial and social losses; it also tends to deprive employees of more liberal plans of benefits which employers may have in effect. Many employers have disability benefit plans in effect which are more liberal in at least some respects than the typical compulsory plans which have been proposed. This greater benefit may be in the form of a higher weekly rate of benefit (even to the extent of continuation of full salary) or provision for commencement of benefits after a shorter waiting period of disability, or provision for continuing benefits in effect for a longer period during disability. The amount of the excess benefits, taken alone, would probably require administrative expenses out of proportion with the amount of benefits payable. It is also likely that an employer or an insurance company administering a supplemental plan would find constant embarrassment arising from the conflict between its claims administration in handling the supplemental benefits and the claims administration followed by the state in handling the compulsory coverage. Under such circumstances it is probable that most of these more liberal plans would be completely abandoned with the introduction of a monopolistic state plan.

In addition to placing a ceiling on the level of benefits, there is an unavoidable rigidity in monopolistic plans which makes it difficult to adapt them to changing conditions or even to correct obvious faults. This is well illustrated by the history of the Rhode Island plan. The administrators of this plan have recommended that certain unsound features of the plan be changed but, so far, have been unsuccessful in obtaining legislation to accomplish these changes. Specifically, they have recommended that the plan be modified so that benefits will not be paid under the cash sickness benefit plan to those who are entitled to Workmen's Compensation benefits, that the benefits paid during incapacity due to pregnancy and resulting childbirth should be limited, and that a separate waiting period should be required for each illness except in cases where the disability is due to a recurrence of a previously compensated illness. Perhaps ultimately these defects will be corrected but in the meantime the fund is being endangered by continuation of admittedly unsound provisions.

The tendency of compulsory plans to follow inflexible and inappropriate patterns is illustrated by the provisions defining benefits. Cash sickness benefits are for the primary purpose of providing a continuation of income to sick employees who expect to return to their old jobs upon recovery. It is logical, therefore, to base these benefits upon the wage history of the employee with his current employer during the period immediately preceding disability. The fact is that substantially all proposals for the establishment of compulsory cash sickness benefit plans follow the pattern of unemployment compensation laws and define benefits in terms of a wage history which may be completely unrelated to the employee's rate of earnings at the time his disability starts. Sickness benefits based on wages paid to employees a year or more prior to the commencement of disability are sometimes inadequate, in comparison with the wages which the employee loses during his disability, while at other times they are so high, in comparison with what the employee would get if he went back to work, that he finds it profitable to remain on the disability roll.

This scheme of basing disability benefits on an old wage history also leads to a confusion between

the functions of the unemployment compensation plan and a cash sickness benefit plan. In the Rhode Island plan an ex-employee who has been unemployed for some time and has drawn unemployment compensation benefits may then, if he can give evidence of disability, claim cash sickness benefits for a period independent of the period of unemployment benefits which he has received. This leads to an extension of the unemployment compensation benefits substantially beyond the period originally contemplated and introduces difficult administrative problems into the cash sickness benefit plan. Disability benefits for unemployed workers can be provided more logically and effectively by amendment of the unemployment compensation law to permit continuation of unemployment compensation benefits during any period that the individual is unable to accept a job because of sickness, subject to whatever over-all limitation on unemployment compensation benefits is included in the plan.

This review of some of the practical problems involved in plans of compulsory health insurance has necessarily been incomplete. There are other problems involved, some of which may be of greater importance than those with which I have dealt. It should be evident, however, that the proposals currently being made for the extension of governmental responsibility in the field of medical care and cash sickness benefits involve fundamental difficulties which have not been adequately explored, difficulties which might easily outweigh the advantages which it is expected would flow from these plans.

Before closing I would like to mention briefly a few possible alternative developments involving the relationships of governmental and private responsibilities for national health.

As I mentioned earlier there is need for further development of the basic health protection of full time, well organized, public health departments for all sections of the United States.

There is need for the development of diagnostic centers. Such centers could be developed locally in association with hospitals, or otherwise, to make available on an efficient and economical basis the medical tools and knowledge already developed. These centers should be developed so as to supplement, not replace, the private medical practitioner. They could be financed in part by public funds or by private gifts and endowments, and in part by charges for services.

There is need for further development and experimentation with voluntary plans for prepayment of the costs of medical and hospital care. This development can be aided by the adoption of a more constructive attitude by the medical profession, by the insurance industry, and by employers. It is not suggested that the physician sacrifice those principles which he considers fundamental to the practise of good medical care, but there is room for him to adopt a more constructive and aggressive approach to the solution of the problems of the high cost of medical care. The individual physician should participate in the development of prepayment plans and should educate his patients to take advantage of prepayment plans.

There should be more experimentation with group practise as a foundation for plans for prepayment of medical costs. The individual physician should tolerate, even though he does not participate in, the development of such plans of group practise if they maintain proper medical standards.

As to the field of cash benefits during sickness, it is the belief of many that further development of voluntary plans of protection will provide such wide-spread coverage that no state action would be appropriate. In any event, where it is desired as a matter of state policy to require universal coverage, it is suggested that the interests of employees, employers, and the public alike are best served by action which places upon employers an obligation to provide for a continuation of income during temporary absences due to disability, with freedom to the employer to provide for such continuation by any of the various methods now used for voluntary plans.

As I indicated earlier, the relationships of governmental and private responsibilities in the field of national health are dynamic. We are in an age of change—an age of both evolutionary and revolutionary change. Much of the struggle which is going on about us today is concerned not so much with whether there shall be a change in our ways of life but rather with the question of how fast and in what direction change shall take place. It is a conflict between forces seeking revolutionary changes and forces preferring evolutionary changes. It is a conflict between those who, seeing some defect in one of our institutions, would change that institution completely and, on the other hand, those who would prefer to retain the old institution with such changes as may be necessary to remedy the defect.

Being of this latter group, I suggest that it is the responsibility of both government and its citizens to seek to remedy the defects in our present institutions, whether they be governmental or non-governmental, in such a manner that their good points can be preserved. This is a slow and tedious process. It requires patience. It requires courage. It requires experimentation. But I am confident that with patience, courage, and experience we can improve our present systems of health care and protection largely within the framework of private enterprise and individual responsibility, thereby achieving many of the advantages claimed for a national health insurance program while preserving the advantages which exist in our present institutions.

PUBLIC HEALTH EXPERIENCES IN THE EUROPEAN THEATRE OF OPERATIONS

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(Read April 18, 1946, in the Symposium on Present Day Social and Economic Aspects of National Health)

At the beginning of World War II it was apparent that populations might be over-run so fast by our invading armies, and that the destruction and disruption of civilian life and institutions would be so great as to slow our progress and hamper and impede our fighting personnel. Moreover, there was reason to believe that the Germans might have depleted and abused a part of the civilian population which would require drastic emergency measures both as a military and a humanitarian necessity. The world now knows the extent to which it was unfortunately true.

It was for these reasons that a new Division of the Army known as G-5 Civil Affairs was established and organized. Its function was to deal with the problems of civil governments and civilians as fast as they were found or created, with the prime objective of furthering military effort by meeting emergency needs and maintaining civilian institutions.

Into Civil Affairs were recruited some six thousand officers and enlisted personnel carefully selected on the basis of their knowledge or aptitude in the various fields of civil administration—administrators, financial experts, legal advisors, economists, supply officers, security and police authorities, fire officials, public health authorities, public welfare officers, public relations officials, and others.

After a period of intensive study and training for several months in England prior to D-Day, the Civil Affairs personnel were divided into groups of varying numbers. The largest consisted of forty to fifty members to be held in readiness to go to the larger cities as they were uncovered. There they would do what was necessary to re-establish local government, reassure the people, and gain their confidence and cooperation by arranging for supplies to meet their immediate critical needs and making plans for the days ahead. Such a group might include one or more officers in each of the various specialties depending upon the needs of each particular place. Smaller groups were organized for smaller cities, and smaller yet for towns and rural areas, where the needs were relatively simple. In some places, for example, only two Civil Affairs representatives were necessary to get things back in shape. If conditions required the services of an additional health officer or other specialists for a brief period of time, they could perhaps be borrowed from one of the larger groups already in the field or requisitioned from a group not yet called out.

As the needs of the civil population were usually most acute when our troops first entered the localities, it was essential that Civil Affairs personnel be present on the spot. Thus it was that certain numbers accompanied the troops on D-Day. Others were available to enter communities well before the firing ceased. Casualties among this personnel were therefore unavoidable.

The Public Health organization of the G-5 Civil Affairs Division at Supreme Headquarters varied somewhat according to the needs but consisted for the most part of some fourteen officers and twelve enlisted personnel. The general plan for Supreme Headquarters called for American and British personnel in almost equal numbers but public health officers for the British army were very difficult to find. The only British public health officer on our headquarters staff therefore was the Deputy Chief of the Branch. He was a man of thirty years of public health experience in the Royal Army Medical Corps and, by virtue of his broad background of knowledge and exceptional skill in developing and maintaining the finest of working relationships, he compensated in part for the shortage.

Our staff consisted of myself and the Deputy Chief as administrative officers, an executive officer and highly competent specialists in communicable disease control, venereal disease control, nutrition, sanitary engineering, public health nursing, narcotic drugs control, veterinary disease control, and general health inspection. In addition, there were three nutrition teams of three members each which were assigned to work in the field under the direction of our specialist in nutrition.

It was our responsibility to formulate public health plans and policies to be issued by Supreme

Headquarters for the instruction and guidance of the Commanders of the various army formations in the field to enable them to meet emergency health requirements of the civil population under their commands. It was likewise our duty to make field inspections to see that these policies were carried out.

One of our most important functions was to develop a system of reporting communicable diseases throughout the liberated countries and to some extent in Germany. It was highly important of course to have current and accurate information as to significant outbreaks of disease, to distribute to the military and civilian authorities concerned, and to institute early and effective action for control. Our Civil Affairs officers and the officers of the Medical Department of the Army located at many different places and widely dispersed throughout the European countries were the principal sources of information and constituted a very good communicable disease intelligence service. They played an important role in preventing the development of epidemics which had been forecast and feared as an inevitable consequence of the war in northwest Europe.

Another important duty was to prepare plans and instructions for the health and sanitary measures required in the handling of some six million displaced persons as they took to the open roads immediately upon liberation from the farms and factories and concentration camps of Germany. A special organization in the Civil Affairs Division at Supreme Headquarters known as the Displaced Persons Branch was charged with the overall responsibility. It depended upon the Public Health Branch for policies and technical advice. The displaced persons were collected as rapidly as possible at Assembly Centers previously planned and set up for the purpose. There they could be fed and cared for pending arrangements for their transportation to the countries from which they had been impressed as slave labor for the Germans.

Once they had reached the Assembly Centers, systematic handling was possible. The rapid repatriation of some four million out of the total of six million displaced persons is one of the most marvelous feats that has ever been accomplished. Trucks, trains, and airplanes loaded with these people on their homeward journey to France, Belgium, and Holland form a picture that will never be forgotten by those who have seen it.

It is my understanding that about a half a million displaced persons remain in the Centers in Germany at the present time. These are the ones who have no place to which they may return or who for political reasons do not consider it expedient to return, or who do not want to return, or who are unable to return for other reasons. They are still being cared for under the direction of the military forces. It was the plan that they be fed from German supplies to the extent that food was available and that it be supplemented by food stocks from elsewhere as required. Their ultimate disposition is a matter for the future to determine.

Under the confused and chaotic conditions immediately following their liberation by the combat troops large numbers of these people took to the open roads and wandered for varying lengths of time before arriving at Assembly Centers. They lived on supplies ransacked from the German houses which they passed and did not do too badly. Not only food but clothing, household equipment, and even pianos and accordions found their way into the displaced persons' camps as contributions from the Germans. I was quite surprised at one Russian camp to hear piano music issuing forth from three different tents.

Small foci of disease, especially typhus fever from the concentration camps, were naturally established at many different points and had to be promptly dealt with to prevent a conflagration. Physical examination and DDT dusting stations were established at crossing points along the Rhine where all who came were adequately treated.

The Public Health Branch was depended upon also for advice to the Civil Affairs Supply Branch as to medical and sanitary and food supplies—the kinds and quantities needed, and the times and places where they should be delivered. Had it not been foreseen a year in advance, for example, that the typhus situation in Germany would require a million pounds of DDT, and had it not been requisitioned, manufactured, and brought from the United States in time to be transported by Army lorries for hundreds of miles through France and Belgium so as to be readily available at numerous distribution centers near the German border when the concentration camps were opened up, the sixteen thousand active cases of typhus found by the medical officers of the Allied Forces in Germany would have created well-merited consternation throughout the world.

Advice in regard to the emergency food supplies required by the civil population from military stocks was a matter of vital importance when the only source of supply was that which came

across the channel and landed on open beaches, at a time when every cubic foot of space was desperately needed to bring ammunition, food, and equipment to keep the armies going and feed the fighting men up front. Sound advice required accurate knewledge of the nutritional status of the people, and the kinds and quantities of emergency food required to meet the most desperate needs. The responsibility for making these determinations devolved upon the nutrition member of our staff who, with several assistants and nutrition teams, ascertained the facts by scientific methods.

The Civil Affairs public health personnel in the field consisted of approximately 175 officers —medical officers, sanitary engineers, dental officers, nutritionists, veterinarians, and others. As already stated they were assigned to field formations and served as members of the Civil Affairs Detachments which went to the various places and helped the civilians meet their needs. Such Civil Affairs personnel were always subject to the orders of the military commander of the area in which they served. Once having been assigned to a field commander they no longer received their direction from Supreme Headquarters except by way of the general policies and directives which were handed down through their commanders.

Having traveled some thirty-five thousand miles by automobile and air through France, Belgium, Holland, and Germany, between the day of the invasion and the day of surrender, I may now mention some of the more important and interesting things that were encountered.

You have heard much of the concentration camps in Germany. Because of their bearing on the health of the general population of Europe through thousands of the pathetic, broken-down, diseased inmates who have returned to their homes, I think you ought to know some of the details in order to understand the future consequences which may ensue. I shall tell you only those things which I have seen with my own eyes in the concentration camp at Buchenwald.

The camp was founded when the Nazi Party first came into power in 1933 and has been in operation ever since. Twenty thousand persons of more than twelve nationalities were inmates at the time of its liberation in April 1945. All were males. One thousand were boys under fourteen years of age. The camp was made up of intelligentia and leadership personnel from all of Europe—anyone and everyone of outstanding intellectual or moral qualifications, or of democratic or anti-Nazi inclinations, or their relatives.

The French inmates for example included four anti-Vichy members of Parliament, professors of the Pasteur Institute, of the University of Paris, of the University of Caen, and the like; also eight high ranking anti-Vichy French generals, French engineers, lawyers, editors, and other professional men of the higher brackets. There was a particular inclination for incarcerating prominent Jews—there being some four thousand among the twenty thousand survivors. They were given even worse treatment than the others.

A few inmates were ransomed by their families from time to time by personal payments to SS officers, and liberated to spread the word among other anti-Nazi leaders and intellectuals throughout Europe, as to the penalties for anti-Nazism.

The camp was in reality an extermination factory. Mere death was not bad enough for anti-Nazis. The policy was starvation combined with hard work, abuse, beatings, and tortures, incredibly crowded and vile living conditions, and untreated illness. By these means tens of thousands of the best leadership of Europe, including German democrats and anti-Nazis, have been exterminated. Prior to liberation the death rate was about 200 a day. Fifty-seven hundred had died or been killed in February; fifty-nine hundred in March, and two thousand the first ten days in April.

During the first ten days of our occupancy, which began on April 13, 1945, our military medical personnel had succeeded in locating 5,490 acutely ill persons. On April 25 I saw, among others, in the hastily devised emergency hospitals 62 cases of acute typhus fever, 323 cases of advanced tuberculosis, and 208 cases of dysentery. Persons suffering from starvation and too far gone to care for themselves accounted for a number of the others, and there were also a number of surgical cases.

Interestingly enough a fairly good surgical department had been a part of the regular equipment of the camp. While very simple, it was outstanding in contrast to the other facilities. The suggestion was made that it was used as a show place at such rare times as visitors might be admitted to certain sections. I spoke at length with Dr. Horner, a surgeon of some repute in the vicinity of Prague, and who had been an inmate of Buchenwald for several years. He told me that he had been able to get almost as good surgical results as those in outside practice.

In general, the condition of the inmates varied depending upon how long they had been there and the kind of treatment they had received. Some were fairly normal in appearance, others showed the effects of abuse and starvation in all degrees. Numbers were either on the point of death, or too weak and emaciated to move off the floor on which they were lying under cover of whatever scraps of cloth or clothing it had been possible to collect. Large numbers who were veritable living skeletons were moving about inside the shacks although it was hardly conceivable that persons with such wastage of body tissues could have the strength to stand or walk. Many were clothed only in thin cotton shirts which came about half way to the knees and which were all the clothing they had had for an indefinite time.

After seeing the pile of naked bodies outside, which there had not yet been time to bury, I was deeply impressed by the appearance of many of the living who showed the same degree of emaciation and almost the same facial expressions as the dead. It was as if someone had restored the breath of life to the corpses and they were moving about or following me with their eyes. One could readily imagine which ones, prior to our ministrations, would have been thrown on the pile of the dead the following morning, and on each succeeding day thereafter.

We were giving intravenous feeding to some who were too far gone to take food by mouth. Protein hydrolysate had been given to some extent where indicated. Those still able to eat were receiving dilute cereal and milk, with gradual increases in the amount and quality of the food as they were able to assimilate it. When food first became available, numbers of persons obtained too much and died. Others suffered from gastro-intestinal disturbances for several days. Stringent measures had to be taken to prevent individuals from obtaining more than the amount intended for him.

The food ration allowed the prisoners by the Germans varied from 500 to 700 calories a day as against 2,500 to 3,600 calories required for adult health. The items consisted of black bread, potatoes twice a week, beet root twice a week served as weak soup, soy bean or other vegetable sausage, jam twice a week, margarine about once a week. Never any greens or fresh vegetables. A heavy deficiency in fats and vitamins. No meat. Meals were prepared and distributed by prisoner personnel under SS guard supervision. Red Cross packages were almost entirely appropriated by the SS Camp Commander who distributed the contents among the SS personnel, to the citizens of the nearby town, and even to Nordic German camp prisoners.

I made inquiry of our inmate guide as to the reasons why some prisoners starved to death while others living under the same conditions and receiving the same food remained in comparatively good condition for an indefinite time. As far as I could gather from the reply, the situation was about as follows:

a. The inmates were practically at the mercy of the SS guards who could treat them any way they liked. If a guard did not like the expression on an inmate's face, or observed some slight infraction of the rules, he could pull him out and have him killed in the Strangulation Room. In a similar manner the SS guards could see to it that some of the inmates whom they did not like received less food than the others, or none at all. This was particularly applicable to Jews. Sometimes the food thus saved was given to favorites and sometimes it found its way into a black market at a profit to the guard.

b. If an inmate lost his food receptacle he could not get it replaced. He might hold out his hands for thin soup or porridge but could not retain enough to keep from starving.

c. As prisoners became sick, or weak from loss of food, they were unable to make their way into the food line and therefore starved to death.

d. I was also told that there were some among the survivors who had "marked" their SS guards and knew where to find them, and would "account" for them as opportunity afforded.

The water supply was piped to the camp. There was also a sewage system. This was partially clogged at the time the camp was uncovered and German civilians were commandeered for the purpose of clearing it out. The latrine serving one portion of the camp was seen, and the condition beggars description. Any normal person would become violently ill after a few moments of exposure to the sight and smell. Inmates with dysentery, which was a common affliction, were frequently unable to get out of the crowded bunk and onto the floor of the shack and so contaminated the others. They were not allowed to leave the sleeping quarters at night to go to the latrine outside. The degradation became so great that filth laden sleeping quarters were the regular thing although they had been cleaned up as well as possible in the period preceding our visit.

There was a Medical Experiment Building known as Block 41. This was used for medical experiments and vivisections with prisoners as guinea pigs. Medical scientists came from Berlin periodically to reinforce the experimental staff. In particular, new toxins and antitoxins were tried out. Few prisoners who entered this experimental building ever came out alive.

For the collection of bodies at the camp in general, a systematic method had been worked out. Roll call was held every evening outside the dormitory buildings. Inmates were required to strip and bring to roll call the naked bodies of all comrades who had died during the past twenty-four hours. A motor truck then drove around the camp, picked up the bodies, and took them to the front yard of the incinerator plant in readiness for the next's day operation.

However, this was not the only source of bodies. Emaciated prisoners who "had been around long enough," or who committed infractions of discipline, or who "knew too much," or who refused to be broken in mind were arbitrarily condemned to death. For instance in some of the dormitories prisoners slept on bare wooden shelves sixteen feet in length and about six feet wide. Sixteen prisoners were jammed into each sixteen-foot section. A break in discipline on the part of any one of these prisoners, particularly an attempt to escape, not infrequently resulted in all sixteen being condemned to death.

Such persons were immediately marched on foot to a small door in the fence of the back yard at a point adjacent to the incinerator building. As the condemned prisoners were hurried and pushed through the door, there was an opening flush with the ground about four feet square into which they plunged, falling down thirteen feet and crashing onto the cement cellar floor under the incinerator room. As they hit the floor of this Strangling Room, they were seized by big SS guards and garrotted with a short double ended noose. They were then hung by the back of the collar on a row of meat hooks fastened to the sides of the wall about six and one half feet above the floor. There were forty-five of these hooks. When a consignment had been all hung up any who were still struggling were bashed by a wooden mallet which I saw. The bodies were left on the hooks until called for by the incinerator crew. The bodies were then piled on an electric elevator which ran from the Strangling Room to the incinerator floor above. The elevator could carry eighteen bodies at one time. The day's quota of about two hundred bodies was made up from one hundred twenty to one hundred forty prisoners who died around the camp and in the Medical Experiment Building, and of from sixty to eighty supplied by the Strangling Room.

The design of the Body Disposal Plant was a marvel of German industrial efficiency. It had a maximum disposal capacity of about four hundred bodies per ten-hour day. All bodies were reduced to bone ash. Thus destroying all "evidence." All gold or gold filled teeth were extracted before incineration. The plant was entirely enclosed within a high board fence. No one except the small operating force of SS personnel was allowed even to look inside the fence, and no prisoner who passed within it, as a worker or otherwise, ever came out alive.

The main floor of the plant contained a battery of six fire-brick incinerators each having a capacity of three bodies at a time, or a total of eighteen bodies. Fifteen to twenty minutes were required for the incineration of a charge. The floor of each incinerator consisted of a coarse grate through which the day's accumulation of bone ash was extracted at the end of the operation. The fire came from a furnace room in the basement, the flames being deflected downward onto the bodies by baffle plates in the roofs of the furnace.

For a period of about ten days in March the coal supply ran out. During this time about eighteen hundred bodies were allowed to collect in the front yard stacked up like cord wood. To the annoyance of the SS this over-crowded the yard with undisposed of "evidence," and a spell of warm weather created a sanitary problem. Burial was a good deal more troublesome than incineration and was out of the customary routine. However, something had to be done so a truck detachment and squads of inmates were organized. The bodies were loaded into the trucks and hauled out of camp. The squads dug one huge burial pit, threw the bodies into it except for one end, and covered it up. Then the SS shot all the members of the squads, threw their bodies into the vacant end, and covered them up.

Shortly afterwards a new supply of coal was received and the process of incineration was resumed. However, the operations were so abruptly interrupted by the arrival of United States armor in the area that the SS had no time to tidy up, and the cycle of operation could be plainly examined and understood. The previous day's quota of upwards of one hundred twenty corpses of prisoners who had died in camp were

parked in a truck in the front yard. The incinerators had not been cleared of unconsumed hipbone joints and skulls, and the bodies of about forty inmates who had died since United States arrival was imminent were stacked up like cord wood against the wall of the yard. These adult corpses weighed only from sixty to eighty pounds having in practically all cases lost from 50 per cent to 60 per cent of their normal weight and also having shrunken in height.

On April 20 the Paris edition of the *Stars and Stripes* carried a story regarding the use by SS officers of the camp of tattooed human skin for souvenirs. I took occasion to investigate at the camp and found that it was true in every respect. The Commandant stated that the wife of one of the SS officers started the fad. When any prisoner happened to have extensive tattooing of any sort on his body he was brought to her and if she liked the design the prisoner was killed and skinned. The skin with the tattooing was then tanned and made into souvenirs such as lamp shades, wall pictures, book ends, and the like. About forty examples of this artistry were found in SS offices and quarters in the camp. I myself saw a number of specimens including a lamp shade.

This concentration camp was by no means unique nor were its methods different from similar camps at Dachau, Belsen, Kleine-Glattbach, and at other points.

One cannot but reflect upon the extent to which persons subjected to such abuse and starvation over a long period of time can ever again become normal human beings. Many gave the impression of being mental and physical wrecks who could not be completely restored. It was impossible to judge of their present mentality because of the difficulty of language. Nor was it possible for me to detect class difference among the worst cases—they appeared to be broken wrecks and if some were persons of education and refinement before entering this camp this was not evident from visual evidence at brief inspection. I gained the impression that the mind was perhaps as anemic and weak as the rest of the body. Future observations may reveal to what extent recovery is possible after such experience as this.

It was only natural that the inmates of these camps should want to get out of the atmosphere and return to their homes as soon as possible after liberation, and that their countries and families should want to have them. In spite of the medical care and feeding that our armies did their best to give them they could not be transformed into cheerful places with the highest standards of service right away. Nor could very much be done to remove the horror of association which was indelibly impressed upon every inmate of the camp. Those who were able to travel, therefore, were taken away by the truck load by the French and Belgian and Dutch representatives and launched on the return journey to their homes. Some died en route. Most were diseased in one way or another. Many had tuberculosis in various stages. The effect upon the future health in the countries to which hundreds of thousands of these people and other war prisoners have returned is something that the future will reveal.

I endeavored to ascertain from German physicians and others with whom I came in contact some of their philosophy in regard to the management of the concentration camps. Without exception, they expressed entire ignorance of the conditions which were found and inability to conceive of how such things were possible. It is my impression, however, that the people in general were well aware that terrible things were going on and that they purposely refrained from finding out too much because of intimidation and a general feeling of helplessness in interfering with the actions of the leaders in control.

This tragic experience serves to show what human beings are capable of doing to one another when all controls are released. I do not believe that Germany is the only place in the world where such things could take place. If it were the policy of political despots almost anywhere to band together the gangsters and criminally minded and most brutal and callous elements of the population and place them in complete authority over the lives of masses of helpless people, it seems reasonable to assume that the same depths of degradation would eventually be reached.

To maintain government by the people, of the people, for the people is the surest preventitive of such abuse. It is fortunate indeed that public opinion fostered by democracy will not tolerate torture and persecution regardless of the provocation and that any deviation is immediately subjected to the glare of pitiless publicity which effectually prevents its spread.

THE BACKGROUND AND ANTECEDENTS OF UNESCO

WALDO G. LELAND

Director, American Council of Learned Societies

(Read April 19, 1946, in the Symposium on UNESCO and American Participation in its Activities)

I

THE purpose of this paper is to furnish the historical perspective that all historians in good standing consider an indispensable preliminary to the discussion of any subject; it may be thought of as a sort of running start.

Our Society itself is a part of the background, and is one of the antecedents of UNESCO. You will recall that our Charter of 1780 contains the following provisions:

> And whereas the experience of ages shows that improvements of a public nature are best carried on by societies of liberal and ingenious men, uniting their labours, without regard to nation, sect or party, in one grand pursuit, alike interesting to all, whereby mutual prejudices are worn off, a humane and philosophical spirit is cherished, and youth are stimulated to a laudable diligence and emulation in the pursuit of wisdom. . . .
>
> And whereas nations truly civilized (however unhappily at variance on other accounts) will never wage war with the Arts and Sciences, and the common interests of humanity:
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> Be it further enacted by the authority aforesaid, That it shall and may be lawful for the said Society by their proper officers, at all times, whether in peace or war, to correspond with learned Societies, as well as individual learned men, of any nation or country, upon matters merely belonging to the business of the said Society, such as the mutual communication of their discoveries and proceedings in Philosophy and Science; the procuring of books, apparatus, natural curiosities, and such other articles and intelligence as are usually exchanged between learned bodies, for furthering their common pursuits. . . .

Obviously our members of 1780 did not foresee that midway in the twentieth century many of their spiritual offspring would be leaders in the Office of Scientific Research and Development and in the production of the Atomic Bomb. They would probably have been more in sympathy with the efforts of others of their offspring who were devising means to protect the cultural treasures of civilization from the results of the inventive genius of their colleague of OSRD. But while this sort of historical speculation need not be carried further, we may take satisfaction in the thought that our high aim of the eighteenth century is reflected in the declared purpose of the United Nations Educational, Scientific and Cultural Organization "to contribute to peace and security by promoting collaboration among the nations through education, science and culture."

The range of the interests of UNESCO is very great, and embraces many areas of activity, including all levels and aspects of education, the creative arts, and the use of the various media of mass communication, such as radio, the cinema, and journalism. The purpose of this symposium, however, is to consider the activities that relate to that purpose of the Organization that is described in its Constitution as the maintenance, increase and diffusion of knowledge "by encouraging cooperation among the nations in all branches of intellectual activity."

I should like to emphasize the fact that UNESCO recognizes the advancement of knowledge through intellectual cooperation as one of its principal purposes. It has been feared by some that, by a sort of reverse snobbishness, the concern of UNESCO is only for what are often described as the "grass roots," an expression which, as I have heard it used, seems to refer to the very young, or the very ignorant, or the so-called "under-privileged." Certainly the members of this Society, which is devoted to the "promotion of useful knowledge," are the last to deny the importance of nourishing the "grass roots," but it must be clear that the continued nourishment of the "grass roots" depends upon a never-ending supply of new knowledge. It is the peculiar task of scientists and scholars to maintain this never-failing supply. The part that international cooperation has in the accomplishment of this task is a major theme of this symposium.

II

It would be easy for the historian to find antecedents of UNESCO in remote antiquity, and to present a lively account of cooperation among scholars and scientists of many countries through

the ages. But much of that account would consist of matters of common knowledge to this audience. We readily recognize the importance of the medieval universities, of the rise of academies, and of the development of societies of scientists and scholars, and their significance in the growth of intellectual relations between countries.

The *formal* organization of international intellectual relations is mainly a phenomenon of the latter half of the nineteenth century. Occasional or periodical international congresses devoted to specific fields of knowledge were organized with increasing frequency. Such, for example, were the International Congress of Anthropology and Pre-History, first held in 1866; the Congress of Orientalists, in 1873; the International Congress of Psychology, in 1889; and the Congress of Historical Sciences, in 1898.

The international congresses, some of which became well established series, prepared the way for the organization of permanent international bodies. In some cases these were permanent committees designed to function between congresses, such as the Permanent Committee of the International Congresses of Philosophy. In other cases international societies of individual membership were organized, such as the International Statistical Institute. International bodies of a federated character came into existence, notably the International Association of Academies, organized in 1900 by the initiative of the German academies. By the end of the first decade of the present century there was a large number of periodical congresses, of permanent committees, of international associations, and of federations which were increasingly active.

The effect of the First World War was greatly to stimulate the growth of international organizations devoted to science and scholarship. The work of the National Research Council of the United States led to the creation of similar bodies by the allied and associated powers, and to the organization of the International Research Council, now the International Council of Scientific Unions, in 1919. About this time, or shortly thereafter, most of the International Scientific Unions were organized, and became federated in the International Council. The International Association of Academies, referred to above, ceased to exist, but the International Academic Union was organized in its place. The scope of the latter, however, was restricted to the humanities and the social sciences, and it was to enable American scholars to take an effective part in the work of this new Union that the American Council of Learned Societies was formed.

The years between the two wars were prolific in new international organizations. The International Scientific Unions, of whose work you will doubtless hear more from Dr. Bronk, formed a broad pattern covering the principal fields of science, but in the humanities and social sciences the pattern was only partial. In addition to the International Academic Union there should be noted, by way of illustration, the International Committee of Historical Sciences, the International Congress of Anthropological and Ethnological Sciences, with a permanent council, the Permanent International Committee of Linguists, the International Society of Musicology, and the International Academy of Comparative Law. Important organizations of related interest are the International Federation of Library Associations and the International Federation of Documentation.

In all these organizations American scientists and scholars took an active and frequently a leading part. Numerous congresses were held in the United States, although the expense of travel made it difficult for a normal number of Europeans to attend them.

These various organizations are voluntary bodies. They do not depend on agreements between governments, nor are they supported from public funds. Except for the payment of American dues in the Scientific Unions, the cost of American participation in them is met from private sources. These organizations are the result of the recognition by scholars and scientists in many countries of the necessity of maintaining close relations for the exchange of information and the cooperative planning and execution of enterprises for the advancement of knowledge. In so far as the scientists and scholars of the various countries enjoy intellectual freedom, this cooperation is unhampered by non-intellectual considerations, but the experience of international organizations since 1933 has demonstrated conclusively that without complete intellectual freedom collaboration in intellectual tasks is impossible.

The immediate problem confronting the international bodies that we have been considering is that of the resumption of their activities. The circumstances are far more difficult now than they were after the close of the First World War. Not only is the material situation much worse, which increases the difficulties of meetings, but the wanton destruction of intellectual resources, the deliberate elimination of intellectuals themselves, and

the restrictions on intellectual freedom which are still to be encountered create a moral situation which is beyond the previous experience of mankind, and which calls for all our wisdom and courage and patience.

III

I have tried to present a general account of the background of UNESCO as concerns the international scholarly and scientific organizations with which we have thus far had most to do. It remains to consider, first, certain activities of our own Government in the field of international intellectual relations, and then the prototype of UNESCO itself in the form of the Intellectual Cooperation Organization of the League of Nations. Without some understanding of these matters we might be inclined to regard UNESCO as something new and unprecedented, whereas it is a natural, almost an inevitable, result of the developments of the last quarter of a century.

The approach of our own Government to active participation in international intellectual and cultural relations has been casual and cautious. Something like a policy first appeared in our relations with other American republics. Mr. Thomson, speaking for the Department of State, will doubtless dwell more fully on this aspect of our joint subject than I can or should. But I should like to point out certain specific steps.

The first of these was participation in support of the periodical American Scientific Congresses, of which the eighth and latest, and probably the most successful, was held in Washington in 1940. The Government of the United States also joined with other American governments in the creation and support of the Pan-American Institute of Geography and History, whose headquarters are in Mexico City, and whose fourth general assembly is to be held in Caracas in August of this year. Still another step was when a Division of Intellectual Cooperation was created in the Pan-American Union.

Probably the most decisive step, prior to 1938, was entering into arrangements with the other governments of the Continent in the Conference of Buenos Aires of 1936 for a general program of cultural relations and exchanges. In 1938 the Division of Cultural Relations was established in the Department of State, and the Government announced that henceforth intellectual and cultural activities, as such, would be an integral part of its program of foreign relations. From that act developments of great consequence and far-reaching scope have issued, and our signature, on November 16, 1945, to the Final Act of the London Conference, presenting the Constitution of UNESCO to the United Nations, was at once a logical conclusion and a new starting point. It belongs to Mr. Thomson to discuss these developments, but as a close observer of these matters of international relations I cannot refrain from stating that no governmental program has ever been more fully or usefully discussed with the competent public, or represents so faithfully the considered opinion of that public. The democratic process has operated at its best, and that in the field of foreign policy.

It remains to describe briefly the only prototype of UNESCO—the Intellectual Cooperation Organization of the League of Nations. Our Government took no part in the support or work of this Organization, although Americans participated in both. The history of the Organization, which is its most valuable bequest to UNESCO, is little known, but it should be well known and understood, for it can be of the utmost benefit to its successor.

The Covenant of the League, unlike the Charter of the United Nations, contained no provision recognizing educational and cultural interests as a concern of the League of Nations. Nevertheless, the First Assembly of the League, by a resolution adopted in December, 1920, requested the Council to consider the international organization of intellectual work. In September, 1921, after a report presented by the French delegate Léon Bourgeois, the Council decided to create the International Committee of Intellectual Cooperation. The Bourgeois report might well have served a similar purpose with respect to UNESCO, for it stated that "no association of nations can hope to exist without a spiritual and intellectual understanding among all members."

Thus the Committee on Intellectual Cooperation was established, and held its first meeting in August, 1922. Its first chairman was Henri Bergson, and among its first members were Mme. Curie and our fellow member Robert Millikan. Albert Einstein declined membership, and H. A. Lorentz, the Dutch physicist, was appointed in his place. When failing health forced the resignation of Bergson, Lorentz succeeded him, and was in turn succeeded by Gilbert Murray. Upon Professor Millikan's resignation from the Committee, another of our fellow members, Professor James T. Shotwell, was appointed in his place by the Council of the League. Numerous other Americans

attended the meetings of the International Committee or of its subcommittees, and took an active part in its work.

The International Committee on Intellectual Cooperation was responsible to the Council of the League, and reported to it annually. The Committee had a section of the League's secretariat in Geneva assigned to it, but its principal operating agency was the International Institute of Intellectual Cooperation in Paris which, although supported almost entirely by a special subvention from the French Government, was responsible only to the International Committee and to the League itself. The Director General of the Institute, after its first few years, was M. Henri Bonnet, now Ambassador of France to the United States.

This central organization—the Committee, its Geneva secretariat, and its Paris Institute—was supplemented by National Committees on Intellectual Cooperation. These were organized in forty or more countries, including the United States. In some countries, members of the League of Nations, they had an official or quasi-official status; in others they were unofficial. The National Committee on Intellectual Cooperation of the United States was wholly non-governmental although some officers of the Government were among its members. It was organized by Professor Millikan while he was a member of the International Committee, and was enlarged and reorganized by Professor Shotwell when he succeeded Professor Millikan. This National Committee still exists, but it will probably vote its own dissolution if and when the proposed National Commission for Educational, Scientific and Cultural Cooperation shall come into being.

How did such an organization operate, and what did it find to do? These are the questions, put in the future tense, that are being asked about UNESCO.

The International Committee met once a year for prolonged sessions in Geneva. The work of the year was reviewed, and decisions were made respecting the continuance of old tasks and the undertaking of new enterprises. Consideration was given to general problems, as well, and the discussions of the Committee, reported in its proceedings, should be required reading for the first members of UNESCO—especially of its Executive Board, which will resemble the International Committee in many ways no matter how hard it may try to be different.

Throughout the year the Institute in Paris directed the activities that were under the sponsorship of the Committee. It compiled information, prepared reports, organized conferences of experts, and carried on a large correspondence. It was the mainspring of the Organization—as the General Secretariat will be of UNESCO. There were standing or permanent committees, such as those for Letters and Arts, for the Sciences, and for Education, and the Liaison Committee of Major International Associations, and there were specialized offices or institutes, such as the International Office of Museums and the International Institute of Educational Cinema; these latter operated separately, though in close relationship to the Paris Institute.

The support of the Organization came, first from an appropriation in the budget of the League of Nations; second from the subvention for the Paris Institute which was voted by the French Parliament and which was supplemented by minor contributions from other countries; and third from private subventions for specified purposes, such as those granted by the Rockefeller Foundation for the International Studies Conferences.

Although the national committees for intellectual cooperation, already mentioned, were outside the central organization and operated quite independently, each in its own country, they were nevertheless a most important part of the Organization as a whole. That of the United States was one of the most active, and was generously assisted from Rockefeller and Carnegie funds. The committees of the other American countries were also active and well organized. The Committee of the United States, which may be considered a prototype of the National Commission for Educational, Scientific and Cultural Relations (if the latter shall be created) collected information needed by the Paris Institute, examined American school textbooks in history and geography for passages which tended to arouse ill will toward other countries, published a comprehensive survey of the *Study of International Relations in the United States,* and engaged in a long and intensive enquiry looking to the improvement of our legislation on copyright—to note only a few of its undertakings.

The national committees met in two general conferences, called by the International Committee, and the second of these, held in Paris in 1937, had some of the characteristics of an international congress of broad scope. It seemed probable that the general conference of national committees would, in the course of time, become an exceed-

ingly important part of the Organization; it may be regarded as the prototype of the Annual General Conference which is to be the legislative and governing body of UNESCO.

There also appeared an interesting tendency toward regional organization within the larger framework. The Scandinavian national committees had many interests in common, as had the national committees of the American countries. The latter held two pan-American conferences—in Chile in 1939 and in Cuba in 1941.

In theory, at least, the program of the Intellectual Cooperation Organization of the League was as broad as that contemplated for UNESCO. It has been criticized, mostly by persons whose contacts with it were slight, for being concerned chiefly with intellectual interests at the upper levels. It must be remembered, however, that the word "intellectual" is in French an exceedingly broad term, quite as comprehensive as "educational, scientific and cultural," and much more convenient.

The range of activities of the Organization may be judged by a few samples:

A quarterly list of translations from and into various languages:

An international guide to archives;

An international catalogue of current bibliographies;

A bulletin devoted to the interests of scientific museums;

A manual of museum administration;

A manual on the technique of archaeological excavation;

Special studies and reports on school broadcasting, on popular libraries and workers' leisure, on the universal adoption of the Latin alphabet, and on unemployment of intellectuals;

International conferences for the discussion of "The State and Economic Life," "Collective Security," and "Problems of Peaceful Change";

International discussions of such subjects in the fields of the arts and letters as "Art and Reality: Art and the State," "The Formation of the Modern Man," "Towards a New Humanism," and "Europe and Latin America";

Colloquia and symposia in the fields of the sciences on "New Theories in Physics," "Application of the Calculation of Probabilities," "Bases and Methods of Mathematical Science," and "Present State of Research on Magnetism."

Finally, the Organization concerned itself with the drafting of international conventions (one of the functions prescribed for UNESCO). The principal of these were for the protection of national collections of art and history and of monuments and works of art in time of war, for the revision of history textbooks, for broadcasting in the cause of peace, and for international copyright.

From among all the activities of the Organization (and I have selected only a few by way of illustration) there remains much unfinished business, and it is to be supposed that such matters will be taken up by UNESCO at an early date.

I have endeavored in this rapid and partial review to point out that UNESCO has a long and notable ancestry, in both direct and collateral lines. I believe that such an organization, in which our own Government fully and generously participates, will work to the great advantage of those intellectual interests to which our Society is devoted. But its effectiveness will depend even more on ourselves, as scientists and scholars and educators, than on Government. It is for us to initiate and to collaborate and to give full evidence of a faith that we can justify by our works.

THE ROLE OF GOVERNMENT IN UNESCO

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(Read April 19, 1946, in the Symposium on UNESCO and American Participation in its Activities)

I VALUE highly the privilege of taking part in this symposium on the United Nations Educational, Scientific and Cultural Organization, under the distinguished auspices of the American Philosophical Society. Discussion concerning the character, purpose, and program of UNESCO is specially useful at this time when the infant agency is passing through what may be its most impressionable period. What is thought and said about UNESCO during the next few months will have effects extending over many years.

In the United States the federal government has moved slowly and somewhat hesitantly toward developing its side of the partnership with private organizations in the enterprise of building understanding with other nations. It was not until 1938 that the Division of Cultural Relations was established in the Department of State. In the same year the Department enlisted the assistance of other government agencies for a program of mutually helpful cooperation with the other American republics which is now carried forward under the direction of the Interdepartmental Committee on Scientific and Cultural Cooperation.

From the beginning it was recognized that the people of the United States acting through their non-governmental groups and organizations must have a free voice and an active part in the cultural cooperation program. Through four conferences held in 1939 the Department of State called into consultation approximately one thousand leaders of the educational and cultural life of the country. Continuing consultation has been facilitated by a group of advisory committees whose members were connected with many of the principal voluntary agencies. These committees have advised the Department on important policy questions and major phases of the evolving program. In addition, the Department has allocated on the basis of contract a number of specific activities to be carried on by private organizations. In the role of leadership which the United States has exercised among the United Nations toward shaping plans for UNESCO the government has consistently sought close association with the voluntary agencies of the country. The United States played a major part in the preparation of the basic preliminary draft for the Constitution of UNESCO which was considered by the Conference of Allied Ministers of Education in London, and with some modifications was laid before the Conference held in November, 1945. Proposals for that draft were worked out in the Department of State, in consultation with other government agencies and with representatives of private organizations concerned with education, science, and cultural affairs. At the San Francisco Conference the group of forty-two consultants to the United States Delegation, representing national organizations in the fields of labor, business, agriculture, women's activities, religious interests, and veterans affairs as well as formal education, supported strongly the recognition of cultural and educational cooperation in the United Nations system. The movement gained further momentum by the unanimous approval in both houses of Congress of the Mundt and Fulbright-Taft Resolutions which called for the organization of a "permanent international agency to promote educational and cultural relations." Subsequently, both before and after the UNESCO Conference in London, the Department of State called together a number of informal groups which provided useful counsel in the formulation of plans for UNESCO and its program. In addition, conferences were organized by such organizations as the Liaison Committee for International Education, the American Council on Education, the American Association for an International Office of Education, the National Education Association, the Independent Citizens' Committee of the Arts, Sciences and Professions, and the Friends Peace Committee of Philadelphia. Regional meetings were held in various cities across the country. Thus the policy of the United States toward UNESCO has been shaped through a process of broad and democratic consultation.

One of the earliest questions faced by the United States delegation to the Conference in London related to the part that governments

should play in UNESCO. The delegation asked itself whether it was proposed to establish an organization of national governments or an organization of representatives of the educational, scientific, and cultural institutions of the various nations.

Behind this question lay an issue of the greatest importance to the vitality of the new organization. On the one hand, it was argued that UNESCO should be a medium for peoples to talk freely to each other; it must be to a unique degree a people's agency. On the other hand, it was recognized that the support of national governments would be essential to the success of the new organization; in fact, they must play a leading role. After extensive discussion, the delegation came to the view that UNESCO should be established as an organization of national governments, but that national governments should in each country associate with themselves non-governmental groups concerned with educational, scientific, and cultural interests.

This basic question was posed in somewhat different form in the course of the London Conference by the French proposal that, in addition to national governments, non-governmental international organizations should be entitled to membership, with voting privileges, in the General Conference and representation on the Executive Board. On behalf of this proposal it was contended that the truly international character of such associations would help to counterbalance the possible domination of nationalistic emphasis in an assembly composed solely of representatives of national governments. While the French initiative was given careful consideration, it found little support. In addition to the difficulty of choosing which associations should be represented in UNESCO and which should not, it was pointed out, and I quote from the pamphlet "The defenses of the peace" (part II, page 19), "that voluntary societies are not responsible bodies in the sense that governments are responsible both to their own people and to other governments; that it would be easy for them to advocate measures which the governments could not or would not carry out—so that futility and frustration might result."

A further factor was the responsibility of governments to provide the budget of UNESCO which some tentative and informal estimates place at $5,000,000 or $6,000,000 annually as a beginning figure. Of this total the United States may be expected to pay approximately one-fourth if the precedent set in the Food and Agricultural Organization is followed. At the same time the conference recognized the value to UNESCO of close cooperation with non-governmental international organizations through the formation of advisory committees, the exchange of observers at meetings, interchange of publications, and other working arrangements, including assignment by UNESCO of specific tasks to such agencies.

The relation of UNESCO to the United Nations Organization further underlines the responsibility assigned to governments in the administrasion of the former agency. While UNESCO according to its Constitution is to have autonomy "within the fields of its competence," it will be brought into relation with the United Nations by an agreement which "shall provide for effective cooperation between the two Organizations in the pursuit of their common purpose." This agreement may among other matters provide for the approval of the UNESCO budget by the General Assembly of the United Nations. UNESCO is to advise the United Nations Organization on the educational, scientific, and cultural aspects of matters with which the latter is concerned. It will present reports to the Economic and Social Council of the United Nations, and its relations with other specialized agencies, such as the Food and Agriculture Organization and the International Labor Office, will be coordinated through the Economic and Social Council. Governments which are members of the United Nations automatically have the right to membership in UNESCO.

The text of the Constitution as finally adopted made it clear that, while UNESCO is basically an organization of national governments, those governments are under obligation to link their peoples closely with the work of the organization. The Preamble to the Constitution declares that "the States parties to this Constitution . . . do hereby create the United Nations Educational, Scientific and Cultural Organization"; and various subsequent articles speak of "the States Members of the Organization" or of "the Member States." But at the same time the Constitution prescribes that "it is in the minds of men that the defences of peace must be constructed." The Preamble declares that UNESCO is created "for the purpose of advancing, through the educational and scientific and cultural relations of the *peoples* [italics mine] of the world, the objectives of international peace and of the common welfare of mankind. . . ."

Further Article VII requires that "each Member State shall make such arrangements as suit its particular conditions for the purpose of associating its principal bodies interested in educational, scientific and cultural matters with the work of the Organization, preferably by the formation of a National Commission broadly representative of the Government and such bodies." The Department of State, acting in cooperation with other government agencies, proposes to take positive steps to carry out this mandate and envisages that the National Commission will serve to maintain a continuous working partnership between the government and the voluntary agencies in the relationship of the United States with the Organization.

The National Commission will serve basically as an advisory, not an administrative body. It is to advise the government concerning the selection of the delegates to the General Conference of UNESCO and advise that delegation and the government in matters relating to UNESCO. It will also serve as an agency of liaison between the government and the educational, scientific, and cultural interests of the country in connection with UNESCO affairs. It is to be expected that the Commission will not only consider proposals referred to it by the government and by private persons and organizations but that it itself will initiate proposals with respect to the activities of UNESCO. It will consider recommendations received from UNESCO and advise the Department of State on appropriate action which might be taken by the national government, state and local agencies, and private organizations on such matters. Further, the National Commission could well review from time to time the progress made in the United States in carrying out the recommendations and in fulfilling the purposes of UNESCO.

How should the members of such a Commission be chosen? It is essential that it should be as representative as possible of all the interests in the United States which would be concerned with UNESCO—the whole broad range of education, including adult education and the educational activities of such groups as organized labor, chambers of commerce, parent-teacher associations, and others; associations of scholars and scientists both in the natural and the social sciences, as well as in the fields of technology, engineering, and medicine; the creative expressions of the human spirit through literature, music, and the fine arts; the work of libraries and museums; and finally the agencies for mass communication such as radio, films, journalism, and publishing. At the same time the Commission must not be so large in size as to be unwieldly; it must be an effective working body.

The Joint Resolution authorizing participation by the United States in UNESCO, proposed in the House of Representatives by Congressman Chester E. Merrow and in the Senate by Senator James E. Murray, reads:

> The Secretary of State is authorized to establish, in fulfillment of Article VII of the Constitution of the Organization, a National Commission on Educational, Scientific, and Cultural Cooperation and to designate for such periods of service as he may determine, not to exceed thirty persons broadly representative of the educational, scientific, and cultural interests of the United States, to serve on the National Commission.

Certain of the witnesses appearing at the hearings held by the Committee on Foreign Affairs of the House on April 3, 4, 5, 1946, argued that the members of the Commission, at least in greater part, should be named directly by private organizations rather than by the Secretary of State. However, the Secretary of State was to choose the organizations making the selection. The thesis of this group was that such a procedure would assure direct representation of the major organizations of the country, better assure the authenticity of the program and safeguard it from control for extraneous purposes.

Other witnesses, including Assistant Secretary of State William Benton found serious difficulties in the above proposal. It would require the Department of State to discriminate among many hundreds of interested organizations, favoring some and passing over others. It involved the further danger of selecting the administrative type of organizational leader and ignoring the creative person who may not feel at home in an organization. It might tend to emphasize the vested interests of organizations.

The positive values of broad democratic participation were recognized in a suggestion that interested groups might be assured a voice by arrangements which would supplement the National Commission. An idea originally proposed by Dr. Waldo G. Leland called for a large national conference to meet periodically, to which any interested group or organization might send a representative. Smaller conferences might be of regional or specialized character.

As the result of this discussion the Committee on Foreign Affairs reported out the Resolution with certain amendments. It increased the number of members in the National Commission from thirty to fifty. They are to be appointed by the Secretary of State for three-year terms, no member serving more than two consecutive terms, thus assuring rotation in office. Further, the Committee provided specifically that the National Commission should call annually or biennially a large national conference and also from time to time smaller conferences of experts.

It may be pointed out that the discussion revealed a difference on means rather than on ends. All witnesses were agreed that as Mr. Benton stated "UNESCO must command the fullest cooperation of the voluntary agencies and the general public, if its purposes are to be achieved and if the activities which it recommends are to be carried out." Procedures must be worked out including the National Commission to assure that the people have full opportunity to take part in shaping UNESCO into an effective instrument for world understanding, and a free voice in criticising its failings or stimulating its positive efforts.

How will this partnership work out in practice? Constructive proposals for UNESCO may be expected from such organizations as the American Philosophical Society which has so long served as the meeting-ground and forum of American scholars. How will ideas from this and other sources find expression in the policies adopted by UNESCO? How can the activities carried on in the International Union of Academies, the International Council of Scientific Unions, and other private international associations be linked most effectively and to mutual advantage with those of UNESCO? How can the recommendations of UNESCO, which will require implementation by both governments, and voluntary agencies, most wisely be assigned for execution? It will remain for experience to provide adequate answers to these and similar questions.

UNESCO then is primarily an association of governments. But it must be more than an association of governments. It must be an instrument for peoples to talk with and to understand each other. Governments of course may speak for peoples; they do and they should. But in matters of the mind and spirit government is feared as a somewhat heavy-handed instrument. In the last analysis government rests on authority, on force. But the advances of education, science, and culture depend primarily on freedom.

A century ago Tocqueville was much impressed with the role of public associations in the civil life of the United States. He remarked that "Where at the head of some new undertaking you see the government in France, or a man of rank in England, in the United States you will be sure to find an association." He viewed these associations as highly useful, and asked, "What political power could ever carry on the vast multitude of lesser undertakings which the American citizens perform every day, with the assistance of the principle of association?"

UNESCO will fail of its greatest opportunity, if it does not marshall the peoples of the world in support of the United Nations and the struggle for peace and security. In that mobilization government has an indispensable role, as leader, as trustee, as partner with the voluntary associations in education and science and culture. But those associations, organizations of the tradition and authority of the American Philosophical Society, also are truly indispensable to the purpose of UNESCO. Joined with their responsibility goes opportunity for them to develop through this new international agency broader and more spacious avenues for the progress of man's mind and soul.

UNESCO offers a new challenge to the spirit of the pioneer. That challenge calls to mind the words that Franklin Roosevelt wrote the night before he died: "The only limit to our realization of tomorrow will be our doubts of today. Let us move forward with strong and active faith."

INTERNATIONAL RELATIONS AMONG SCIENTISTS

DETLEV W. BRONK

Director, Johnson Research Foundation, University of Pennsylvania

(Read April 19, 1946, in the Symposium on UNESCO and American Participation in its Activities)

It is appropriate that the American Philosophical Society should sponsor a discussion of the international relations among scientists, for it is in the spirit of our earliest traditions. Throughout the history of science there are few who have labored more effectively than our founder to break down the national boundaries which impede the progress of science and restrict the benefits that derive from new discoveries.

Those who are concerned with the conduct of international affairs will benefit from a consideration of Franklin's career as a scholar and a diplomat. He was fitted for his tasks in foreign capitals by many qualifications, but not the least of these was his eminence as a man of science. A fellow of the Royal Society of London, of the Royal Academy of Science at Göttingen, of the Academy of Sciences of Paris, of the Academy of Sciences, Letters and Arts of Padua, of the Imperial Academy of Sciences of Saint Petersburg, Franklin went on his diplomatic missions as a respected citizen of the world of science, as well as of the American Colonies or of the new United States he had helped to create. Because of this we know that he was heard as one who had contributed to the welfare of all peoples, while seeking, as a patriot, to improve the material and political circumstances of his own countrymen.

Of especial importance was the fact that he carried to his tasks an instinct for internationalism that had been developed through his scientific career. It is not unreasonable to assume that this gave him a tolerance and a breadth of outlook that favored the course for which he plead and gave it reasonableness. It was this quality that prompted him in March of 1779 to address "All Captains and Commanders of armed Ships acting by Commission from the Congress of the United States of America, now in war with Great Britain" this directive:

> Gentlemen,
> A Ship having been fitted out from England before the Commencement of this War, to make Discoveries . . . in Unknown Seas, under the Conduct of that most celebrated Navigator and Discoverer Captain Cook; an Undertaking truly laudable in itself, as the Increase of Geographical Knowledge facilitates the Communication between distant Nations, in the Exchange of useful Products and Manufactures, and the Extension of Arts, whereby the common Enjoyments of human Life are multiply'd and augmented, and Science of other kinds increased to the benefit of Mankind in general; this is . . . to recommend to . . . you, that . . . in case the said Ship . . . should happen to fall into your Hands, you would not consider her as an Enemy, nor suffer any Plunder to be made of the Effects contain'd in her, nor obstruct her immediate Return to England. . . .

Had we more ambassadors who possessed such a sincere and practical basis for internationalism, it is reasonable to hope that the affairs between nations would run a more wholesome course. Were there more scientists and scholars who possessed Franklin's sense of social responsibility, such ambassadors might be more numerous.

Franklin's concern for the affairs of science beyond the bounds of his nation has characterized scientists of all ages. National boundaries and national customs are meaningless and of no significance in the study of most natural phenomena. The properties of inorganic matter and the behavior of living organisms under controlled conditions are not affected by the limits of states. Natural phenomena observed anywhere must be fitted into a consistent pattern of universal validity. This is the basis for the world-wide unity of science.

To be an isolationist in science is to handicap one's own accomplishments. The course of new discoveries starts from the territory of established knowledge; the genesis of new ideas is catalyzed by the work and thoughts of others. Recognizing this, scientists were among the first to realize the practical dependence of their work upon the efforts of those in distant lands. Together with the traders for rare goods they have sought intellectual products and new discoveries wherever they were to be found. Out of this desire for the practical advantages which can be gained from the works of others has come that admirable phrase: my foreign colleague, so frequently heard in scientific circles,

with all the wholesome implications of the word colleague or partner. It is worthy of emphasis that this desire for international cooperation derives from no unique nobility of spirit but comes rather from the simple realization of the personal advantages that derive from a free exchange of ideas. If scientists are better prepared for the acceptance of the principles of world unity, it is because they have longer realized the benefits that come from such cooperation.

There is one further circumstance which influences the international attitudes of the scientist. When he considers the social usefulness of his accomplishments he realizes that he is truly a citizen of the world. A new chemical agent for the treatment of disease is of potential benefit to all men; the laws of electro-magnetic induction discovered by Faraday, the Englishman, have eased the labors of the citizens of many countries; the observations of Galileo and Copernicus and Newton have increased the intellectual horizons of no one national group. And so, the scientist must realize that the furtherance of scientific research in all countries increases the spiritual and material resources of all nations. To further scientific investigations is a common responsibility and a common advantage.

Moved by these ancient convictions, scientists have developed means for their mutual assistance and for the world-wide dissemination of their thoughts and discoveries. Such activities began with their earliest formal associations. The Accademia dei Lincei of Rome, first of the academies of science, and forerunner of the Accademia del Cimento, as early as 1609 laid plans to establish "common, scientific, non-clerical monasteries, not only in Rome, but in the four quarters of the globe, for scientific cooperation. There was to be a museum, library, printing office, besides optical instruments, machinery, botanical gardens, laboratories—everything that belongs to the study of science. In each house every observation, every discovery, was to be communicated without delay to the head house and to all the sister houses." A similar purpose is subsequently found in Bacon's "House of Solomon," wherein he proposed that "for the several employments and offices of our fellows; we have twelve that sail into foreign countries, under the names of other nations, who bring us the books, and abstracts, and patterns of experiments of all other parts. These we call Merchants of Light." This international ideal was an essential factor in the early activities of the Royal Society of London, which took root from the seeds of Bacon's proposals, as may be judged from a poem by William Glanville written in 1660, while the Society was forming at Gresham College:

> These are not men of common mould,
> They covet fame but condemn gold.
> The Gresham College shall hereafter be
> The whole world's University.

The practical accomplishment of this aspect of the Royal Society's undertaking was charged to the secretary, and we find Oldenburg, the first incumbent of that office, describing among his duties: "writes all letters abroad and answers returns made to him, entertaining correspondence with at least thirty persons." Because the reading of these communications from foreign scientists became so important a part of the meetings of the Society, one of their fellows, Robert Keck, in 1719 left £500 for the support of a fellow who should carry on a foreign correspondence. Thus began in 1723 the office of Foreign Secretary.

The importance of international relations was recognized from the very foundation of our own American Philosophical Society. In the earliest records of the Society, dated 1768, there are in the List under October 18:

Dr. P. Burgius, Professor of Natural History, Stockholm
Christian McGee, LL.D. of Heidelberg
Dr. Cullen of Edinburgh
Monsieur Buffon at Paris.

The advantages of such collaboration soon became evident, undoubtedly to the satisfaction of our practical minded founder. For under the date of 16 January 1769 there is a note that Dr. Cirillo of Naples sends thanks for being proposed for membership, and intimating "that they have in Italy a great many trees, fruits and plants . . . of great use to human life and which may be easily introduced into America," which he then offers to do.

As the research fostered by the academies grew in volume, the correspondence of secretaries and of individuals became inadequate for the exchange of information between scientists of different countries. To meet this need there was evolved the scientific journal. The first of these, the *Journal des Scavons,* was published in Paris by Denis de Sallo in 1665 and was followed three months later by the *Philosophical Transactions* of the Royal Society. They were truly international in scope. In the first year the *Journal des Scavons* contained articles by Bausch and Sachs of

Germany, by Divini the Italian lens maker, by Mariotte of France and a review of Hooke's "Micrographia." Similarly, the *Transactions* constituted an international battle ground of scientific opinions; for example, when Auzout had a different view from Cassini, they communicated, through the London publication. From then until now, these publications and their many followers have played an important role in the international relations of scientists.

At their best, however, the scientific journals lack certain of the intimate values of personal correspondence and of the still more significant intellectual stimulus of personal contacts. If I had suspected that my own valuation of such associations was too high, owing to my peculiarly happy relations with foreign colleagues, those suspicions would have been dispelled by my European experiences of these past three years. The eagerness with which war-isolated scientists have sought to resume their interrupted discussions and their craving for the opportunity to live again in the stimulating environment of some foreign laboratory are powerful testimony for the importance of these intimate scientific associations. The real reasons why we do the things we do, the causes of our failures and of our success, the true spirit and faith of our scientific adventures seldom find their way into a scientific periodical. And yet they are powerful factors in a scientific career. These and the personal observation of experiments in progress are experiences to be gained only by the free movement of scientists throughout their world-wide realm.

Thus, who can say that the youthful Franklin of nineteen did not gain life-long values from his acquaintance at that age with Sir Hans Sloane, President of the Royal Society, and with Dr. Henry Pemberton, who was then editor for the aged Newton? Or that he did not derive continued stimulus and enthusiasm from his later association with the leading scientists of many countries? Certainly we know Franklin gave much personal encouragement to young Joseph Priestley and started him on his experimental researches. And, as Professor Bernal has pointed out, in more recent times "the appearance of the Bohr theory of the atom, which is the basis of all our modern physics, occurred because Bohr, the Dane, who had absorbed in Germany the quantum theory of Planck, went to work in Rutherford's laboratory at Cambridge and there came in contact with the nuclear theory of the atom."

With the rapid growth of scientific endeavor in many countries, the older, informal means for international collaboration became inadequate. Accordingly, there began to develop organized efforts for the pooling of information, for mutual undertakings, and for the periodical convocation of scientists studying common problems. One of the earliest of these was the Bureau International des Poids et Mesures, which was established at Sèvres in 1873 as the outcome of an international commission constituted in 1869 for the construction of metric standards. Even earlier there had been founded in Berlin the International Mid-European Goedetic Association, and there followed later the International Seismological Association.

Another effort of this sort grew out of an informal association of the Academies of Munich and Vienna and the Royal Societies of Göttingen and Leipzig. In 1898 they invited the Royal Society of London to join with them. This the Royal Society agreed to do, provided the Association were so extended as to assume a fully international character. In the following year the Académie des Sciences of Paris, the Accademia dei Lincei of Rome, the Imperial Academy of Sciences at St. Petersburg, and the National Academy of Sciences at Washington joined with the others and thus formed in 1900 the International Association of Academies. With the disintegration of international relations during the First World War, this organization fell apart; subsequently the resumption of its activities became difficult because of the thorny problem of the status of scientists from enemy countries. Accordingly, its functions were assumed by a newly constituted International Research Council which included representatives of the Allied nations and of several neutral countries.

These two organizations are worthy of mention for reasons beyond their historical significance. The dissolution of the one by the international strains of war and the long controversy within the second concerning the admission of former enemy countries illustrate the inevitable effects of national conflicts on the international relations of scientists. The resolution of these problems is not as simple as in the days of Franklin's letter of safe passage for Captain Cook.

Of more immediate pertinence to our discussion is the nature of the activities in which these organizations were most effective. This can be inferred from the fact that in 1931 the name of the International Research Council was changed to the

International Council of Scientific Unions. That was in recognition of the fact that the most important development under the council was the growth of the separate scientific unions. The reason lay in the fact that international cooperation flourishes most, and most naturally, when there are common tasks to be performed, and when their performance requires operations over wide geographical areas. Therein lies the success of the Unions of Astronomy, and of Geodesy and Geophysics and of the International Bureau of Weights and Measures. For these same reasons, we may assume that the most favorable fields of science for the further development of international cooperative undertakings are those which of obvious and natural necessity require investigations in many lands. Such are oceanography, epidemic diseases, meteorology, climatology, and astronomy. Likewise there is a sound basis, as Professor Shapley has suggested, for the creation of international institutes of science which employ extremely expensive equipment, such as great telescopes, unavailable to national groups with limited resources.

Excepting such cases, however, the international relations of scientists seem to develop most favorably through the relatively unorganized and natural associations of groups and individuals. The occasional or periodical congresses of workers in the several specialties are of this character. They encourage international travel, they provide forums for international discussions and debate; above all else in value, they foster those intimate associations and friendships among scientists of all countries, so important to the progress of research and understanding. Unfortunately, however, they have been available to the few who could save from their meagre salaries the necessary funds for travel. Thus, the benefits have been denied to the young who could profit most.

This leads me to the need for broadening the scope of our international relations. In the affairs of the academies only a few participate directly. The work of the unions is done by those who have attained some eminence. The congresses are for the financially competent. The great majority of scientists have only their journals as a means for participating in the world-wide work of science.

There has been one important corrective of this situation. The Rockefeller Foundation, the Commonwealth Fund, and the Guggenheim Foundation have through their fellowships broken down the financial barriers to the movement of young scholars from one country to another. Thousands of fellows of these foundations have gained the best scientific training available anywhere, without regard to nationality or to the chance of family fortunes. What is more, they have enjoyed the comity of international scientific fellowship under the most favorable and natural circumstances.

I am not one who believes that the international exchange of relatively few scholars has any powerful, immediate effect for good-will among nations. The causes of friction are too numerous, too complicated, too irrational to be so easily corrected. But scientists are also teachers, and latterly publicists, so their influence is numerously multiplied through their pupils and their public. Accordingly, these foundation fellowship programs are bound to yield high dividends in international understanding. Of more present social value, perhaps, is their profound influence on the quality of scientific research and thinking, to the benefit of all nations. If our government assumes more responsibility for the training of scientific personnel, as is contemplated in the several bills for the creation of a National Research Foundation, the administrators will do well to follow the wise example of the private foundations. The scientific interests of a nation will be best served by giving to its youth the finest training that is available, wherever it may be found.

Some day, indeed, national governments may realize that the mutual support of scientific research is to the interest of all the several nations. A cure for disease discovered by a worker in Paris will probably rest upon previous research carried on in many countries. The cure will be as beneficial to a sufferer in Philadelphia as it would have been if made in Philadelphia or in New York. Scientific research conducted in a spirit of freedom and published without restriction increases the welfare and resources of all nations. Accordingly, it is of more than national concern that the work of a competent scientist anywhere should be fostered. I know of only one agency that has, thus far, adopted such a world-embracing view of scientific effort. Here again we must pay tribute to the Rockefeller Foundation for supporting talent wherever it is to be found. They have set a worthy standard for the United Nations Educational, Scientific and Cultural Organization.

It is with this long tradition of scientific internationalism that the scientist of today faces new situations in a world which is conscious of the need for international unity, but is still fragmented by national prejudices. Fast travel and com-

munication will aid our former efforts for collaboration. But the rapid growth of scientific knowledge and scientific research coupled with more numerous barriers of language and suspicion and national restrictions create new difficulties.

Scientists themselves are meeting this challenge by strengthening and adapting the methods they have evolved in the past. To implement these efforts the Division of Foreign Relations of the National Research Council has largely increased the scope of its services. Individuals are being selected, each of whom will continually study the means for dealing more effectively with science and scientists in some one country. Others are selected to aid international relations in a certain field of science. Committees have been formed to assist scientists here and abroad in the exchange of scientific literature, and of scientific personnel, in the wider usefulness of apparatus and new methods of experimentation, in the work of international unions and congresses. Of primary importance, the National Research Council will do all that is within its power to help UNESCO aid the scientists to fulfill their natural functions.

In this new organization of the United Nations, scientists should find powerful aids to the methods they have evolved for international cooperation. It is gratifying to find that our State Department is formulating plans for the organization with full regard for our traditional procedures and existing institutions. They contemplate no forced, unnatural activities which so often accompany new undertakings, to the impediment of our proper scholarly work. To facilitate this work is their only purpose: by providing financial aid for the exchange of students and mature scholars between nations; by developing means for the publication and dissemination of the results of research, that will somehow overcome the barriers of language; by making the instrumental means of research more available; by fostering mutual programs of investigation in fields such as meteorology and oceanography, where such cooperation is needed are but a few of the challenging opportunities for service that await UNESCO.

Of greater significance is the role it should play in translating scientific discoveries into the improved welfare of the citizens of the world. Science has made possible for all people the material advantages now enjoyed by few. She holds the promise of benefits now undreamed of. If UNESCO can make these benefits more widely available, she will be a true ally of the scientists in fulfilling their function, defined by Francis Bacon as "the enlarging of the bounds of human empire, to the effecting of all things possible, through a knowledge of the causes and secret motion of thing." Indeed, through science nations can peacefully gain those material benefits which they have sought fruitlessly to acquire through war.

There is a passage in the preamble to the Charter of UNESCO which runs thus: "Since wars begin in the minds of men, it is in the minds of men that the defenses of peace must be constructed." Here is a function of which all scientists will approve. Through an organization with such a purpose they can become more powerful agents in the relief of ignorance and in the dissipation of prejudices. Scientists and UNESCO have no more important opportunity for enriching the intellectual and spiritual lives of all people and for the removal of the causes of war.

We should have no illusions as to the ability of science quickly to improve the welfare of men. She has no unique power to create a more peaceful world. But science has in the past liberated men from the uncontrolled domination of natural forces and from ignorance and superstition. So it gives promise of freeing men from the imagined necessities for greed and conflict—by increasing their intellectual and material welfare. If this be our world-wide goal, there must be freedom for scientific effort, unbounded by the artificial limitations and selfish interests of national boundaries. This I take it is the mission of the United Nations Educational, Scientific and Cultural Organization.

INTELLECTUAL COOPERATION IN THE SOCIAL SCIENCES

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(Read April 19, 1946, in the Symposium on UNESCO and American Participation in its Activities)

UNESCO, more than any previous organization within our knowledge, summons the intellectual world to assume a *political* task that is wholly consonant with the ideals of scholarship and with the integrity of the liberal arts. The task demands that UNESCO be a dynamic, not merely a cooperative organization. It has a much larger opportunity in this respect than its immediate predecessor, the Committee on Intellectual Cooperation. It should not limit itself to the interchange of knowledge, to the business of making more accessible to the intellectuals of each country the contributions of every other, important though that business is. UNESCO must be creative in the realm of human culture. Otherwise it will not fulfill the mission expressly assigned to it, that of aiding "to construct the defences of peace in the minds of men." It is challenged to dispel not only ignorance but also prejudice. While it is properly called upon to enlighten each people concerning the ways and lives of the others it must go considerably further if it is to "educate humanity for a peace founded upon the intellectual and moral solidarity of mankind."

The goal of science everywhere is the discovery and exploration of the more inclusive order in which every unit, constituent, or field finds its relation to all the rest, is given its due place and proportion, and is seen in its perspective within the total scheme of things. There is entire accord between this goal and the function of UNESCO, to explore the bases of mutual understanding, to discover the common firmament that is deeper and more enduring than the differences between groups and races and peoples, and to propagate the knowledge of it in order to build and to sustain the larger scheme of human values. The strength of the United Nations, as of any other organization, depends on the community of purpose and interest on which it rests, not on the consensus of its policy makers at the top. There are always sharp disagreements over policy, and on that level the alternatives are merely compromise and conflict. Continuous compromise, unless the purpose is strong and deep, breeds first irritation and finally cleavage. Unless the constituents of an organization are bound to it by a deeper allegiance than considerations of policy it will not withstand the tides of change. The foundations must be strengthened by the creative forces of cultural identification, by the cultural commitments that are more abiding than the calculations of immediate advantage. The peoples must be enlisted or the governments will fail. A world organization must conspire with the forces that make and move the world, and these are the forces of which scholars, scientists, artists, thinkers, educationalists are the interpreters and even the custodians. The humanities, the sciences, the philosophies, and the arts must assume on a larger scale their role of intercommunication, of community-making. As they did in the Middle Ages, but now with wider vision and with greater power they must create the spirit of the more universal community, without which there will not arise the spirit of the more universal law.

It is this conception of the function of UNESCO that inspires the remarks that follow. Their object is to make some broad suggestions regarding a program in the area of the social sciences. The social sciences have a particular mission in the furtherance of the cause of the United Nations. Not only can they join with the other sciences and arts in the cooperative enterprise of strengthening the bases of mutual understanding but they are specially qualified to explore the conditions of understanding, to discover the obstacles to it, and to suggest ways in which these can be overcome. For example, one obstacle to the establishment of a world community is the prejudicial concepts that peoples entertain of one another. The division of nation from nation, like the division of group from group, foments socio-psychological distortions of the social reality. The actual differences of people from people, particularly their cultural differences, constitute a very enticing field for scientific investigation. In the workaday world these differences are continually misconstrued. Our interests, our allegiances, our relative positions in the competitive world are emotionally projected into the

images that represent for us these other peoples, and in the eternally changing conjunctures of our relation to them these images often undergo rapid transformations. But as they do we merely exchange one distorted picture for another. The pragmatic determination of our concepts falsifies our world and makes it harder to discover the true foundations of social understanding.

The scientist must believe that the best foundation is truth and that therefore, the pragmatic is often the enemy of the practical. In the long run and often even in the short run men fight a losing battle against the truth. We are scientific enough in studying the cultures of primitive peoples but we have not yet the impartiality to study scientifically the ways of the great nations. I suggest that here too the truth if it were sought would make us free, free first from certain prejudices, and next, if we could spread the truth enough, from the wasteful and confused conflicts that are directed by false conception of the relation of our well-being to that of other peoples. No one can read the history of peoples or their governments without a sense of the endless futility and ruinous folly, ending always in universal loss, that have characterized this aspect of human affairs.

I should therefore place as a long-range goal for UNESCO the laying of the scientific foundations for the interpretation of people to people, through the comparative study of their ways, their achievements, their problems, and of the historical and environmental derivation of such differentiations of a common humanity as they may exhibit. I am not pretending that this better knowledge will obviate the conflicts between peoples, will reconcile clashes of interests, and turn the sessions of the United Nations into meetings of the Society of Friends. Between nations, as between all groups, relative interests and relative position will always engender differences of policy and conflict of aims. The danger is that relative interests will become absolute, outweighing the far greater common interest and destroying the basis of unity. Mutual understanding can prevent that catastrophe. Conflict will never cease but with mutual understanding it will take place on another level, with far less waste and friction. The relations of the peoples will far less than before be jangled into hopeless blind enmities, in which policy is confounded by passion and the well-being of them all becomes the plaything of the men of power.

Before UNESCO can advance very far toward this goal it must undertake various immediate tasks. For example, it is of little avail to seek to build mutual understanding between the nations unless the results of its labors are made accessible to them. I conceive that the educational efforts of UNESCO will be directed not solely or even mainly to the community of scholars, but to the peoples themselves. Its contributions must be translated into the language of the workaday man. And first of all there must be no barrier to access. There must be no sanctity and no censorship against its truth. Which means that the peoples must have the right to listen and to learn. The primary barrier against understanding must be assaulted everywhere. UNESCO must use all its persuasive powers to aid in the opening of communication, so that the written word shall not be unwinged, so that the voice of the radio shall be as free as the air through which it travels.

The radio opens up various interesting possibilities of international communication that have still to be explored. For example, might it not be feasible for UNESCO to sponsor and organize world-wide international programs? At first these might have to be limited to the only cultural medium that is not restricted by the frontiers of language—music. The United Nations needs some symbols of its unity. One of these might be a great festival, on a special Day of the United Nations, for which day UNESCO might plan a world-wide program of this kind. Furthermore, in order that in due course the living word shall carry over the earth, UNESCO might set itself to considering the difficult question of a common medium of speech, as a second tongue of all the peoples. When the ends of the earth are brought together by the advance of technology, when the physical means of communication and transportation are revolutionized, the education of the children of the future, and even of the present, clearly calls for some such development.

Before I pass from these major objectives, which to some may appear overambitious or grandiose but which I regard as the simple and logical commitments of our culture to our needs I shall touch on one other problem of education for the world of tomorrow. It is clear that some mitigation of the ethnocentricity of our education is greatly needed if we are to attain such a degree of understanding and cooperation within the United Nations as alone can assure against universal ruin. No one should seek to diminish the allegiance of men to their fatherlands but every scholar should work and protest against the falsifications

of truth by which that allegiance is falsely promoted. This falsification is stimulated, for example, by the way in which history is taught to the young, in our own land and in all other lands. Is it not possible to attach due importance to the interest and pride that every nation cherishes in its own history and yet to set that history in its proper perspective against the history of mankind? Is it not possible to extol the contributions of one's own nation and yet show fairly how without the contributions of other nations they would never have come into being? Is it not desirable to acknowledge that many achievements attributed to nations as such are not in any proper sense national at all but the work of the selected and gifted minds who appear, like the wind blowing where it lists, now in this land and now in that? Would it not be wise as well as scientific to deal objectively, in teaching the young, with the errors and gross shortcomings of our historical figures, as well as with their virtues and their glories?

These are elementary issues, but there lies beyond them a more searching question. Why is it so difficult to attain objectivity in historiography? The question concerns not the narrative of place and circumstance, the record of what men have done and suffered, but the exposition of the sequence of cause and effect, the assessment of the relation of policy to performance, the attribution of significance to events and to trends, and the selective presentation and due proportionment of the historical scheme and the environmental setting. In this field the judgment of scholars will always vary with their fundamental philosophies, but cannot the historians of many lands, and of the East as well as of the West, combine in a great enterprise to trace the major currents in human affairs so as to reveal in some measure the history of mankind itself? Why should this task be mainly relegated to amateurs? Historians of many minds have not infrequently got together to write the story of a people or of an age. Could they not also build a history of mankind that would be not a compendium of the histories of different countries differently told but a genuine attempt, not lost in the multiplicity of its details, to exhibit the ever-changing roles of the peoples in the making of the world we now inherit? And might not UNESCO organize and foster this monumental task?

I have taken the vast field of history as an outstanding case of a social science that has been confined and cramped by ethnocentricity. But it is not alone in that respect. Sociology, for example, has suffered from the same limitation, and here there is perhaps less excuse. For sociologists have been preeminently concerned with social relations as such. Their studies have not been directed, for the most part, to the particular sociologies of nations in the sense in which historians have written the histories of particular nations. Yet they have exhibited a too parochial point of view and have too little profited by the approaches, the methods, the insights, and the theories developed in other lands. American sociology is too American, not because it is concerned about American conditions but because it is too unconcerned about non-American contributions to the common field. In the same way French sociology has been too French and German sociology too exclusively German.

UNESCO can do much to remedy this condition over the whole area of the social sciences. On the whole, international conferences have in the past done relatively little, at least in the area of the social sciences, to bring into effective and stimulating contact the members of the various scholarly organizations. They have been infrequent, inadequately financed, and insufficiently representative. I submit two suggestions for the consideration of UNESCO. One is that some of these conferences should be planned around programs specifically dedicated to the current problems of the United Nations. Such conferences could sound out the potentialities of effective cooperation on matters of international economic, social, and educational policy, could discover the limits of consensus and at the same time clarify the nature of the differences that lie beyond these limits, which itself may be a way of enlarging the common ground. The Social and Economic Council and other organs of the United Nations might find it advantageous to formulate projects for UNESCO that could be made the themes, after due preparation, of such conferences.

Another suggestion is that the members attending the conferences should not be selected for honorific reasons, that seniority or eminence should be secondary considerations, and that opportunity, and the necessary financial aid, should be available for the younger men who show promise of becoming the intellectual leaders of the future. International conferences should play a more resounding role than they have done in the past. The National Committees of UNESCO can do much to prepare the way for their success and among other things can see to it that the men

specially qualified in the studies most relevant to conference themes are brought to the attention of the proper authorities.

The more consideration we give to it the more are we impressed by the rich variety of important projects to which the social science division of UNESCO can devote itself. Within my limits I must confine myself to the mere mention of a few types of scholarly inquiry serviceable to the cause of the United Nations. In the first place UNESCO can do much to promote a common frame of reference for international studies. For example, it could deal with the problem of devising a workable basis for comparative cost-of-living and standard-of-living investigations and more generally it could work out plans for uniform or at least readily comparable systems of statistical indices. UNESCO has here certain advantages just because it is not a policy-making body or an official organ of the United Nations. It can discuss matters without the sense of political commitment that weighs on the members of the international organization proper. It could examine the more freely such questions as the relative advantages of different national systems, say in the field of social security. If it held, for example, a conference to explore a monetary problem it would not be a case of Mr. A presenting the position of England and Mr. B that of the United States. It would have the same advantage if it undertook to examine, say, the variant conceptions of human rights in the political realm that are dominant in different countries and to seek for some common measure of these that might perhaps one day be incorporated in an international charter of human rights.

In making these suggestions I am going on the assumption that the members of UNESCO, though they may be appointed by the several governments, will not be appointed as spokesmen of these governments but as the free representatives of the cultural life of their respective countries. I trust that when Mr. Thomson called UNESCO an association of governments he did not mean it in any sense contrary to this assumption. Were it otherwise the creative opportunity of UNESCO would be shackled from the start.

The activities of UNESCO, in fulfillment of its broad commission to advance the cause of mutual understanding and to lead the nations to a "truer and more perfect knowledge" of one another, fall into two main categories. One is to contribute to this knowledge, to explore the grounds of mutual understanding, the other is to propagate this knowledge. We have dealt mainly on the former of these activities and before turning briefly to the latter we would call particular attention to a task of the social sciences that closely binds the two together. We referred at the outset to the prejudices, the false images, the so-called stereotypes, that groups and peoples entertain concerning one another. Now while it is exceedingly easy for the members of every group to see other groups in the form of grotesquely simple generic images that are always distorted in one direction or another it is an extraordinary, difficult thing, even for a social scientist, to apprehend the true character of a social group. The difficulty is particularly great when we contemplate so complex a community as a modern nation. We may indeed question whether it is possible to apprehend the being or the character of a people. It holds within its endless diversities and yet it seems to retain throughout its changes some elusive but distinctive quality. But when we think we have grasped this quality it surprises us by new and unexpected manifestations. Our traditional manner of conceiving and portraying collectivities of all kinds, not merely nations, is unscientific. And just as we forever entertain erroneous conceptions of nations, so do we concerning those aspects of national existence that most dangerously lead us into strife. What, for example, do we mean by "national interests"? How do we assess it? How do we segregate it? On what do our calculations rest when we claim that it is injured, say, by the economic advance of some other country? These are only a few of many questions on which we need clearer thinking, and in the clarification of which UNESCO could do signal service.

Finally, to return to our starting point, the more we contribute to the advancement of knowledge in this field the more we add to the intellectual foundations of our one world. In his *Protagoras* Plato recounts the famous tale of Prometheus and Epimetheus. When the gods fashioned the creatures of the earth Epimetheus distributed among them the means of self-preservation, and to some he gave strength and to some swiftness, to some he gave sharp tooth and claw, to some he gave the power of concealment, to some he gave great fertility. But he overlooked man who alone of all creatures remained naked and protectionless. So to save man from destruction Prometheus stole fire from heaven and the arts that can utilize it and gave them to men. But they lacked still the art of government and so they set to destroy-

ing one another and were again in danger of extermination. But Zeus took pity on them and bade Hermes carry to them the gifts of reverence and justice to be the bond of union between them. When Hermes asked whether these arts should be distributed like all the other arts, to special practitioners, to the experts, the Lord of Heaven answered, "No. They must *all* share these arts, for otherwise states cannot endure." The moral has a wider range today. It is not enough for the students of society and government to explore the grounds of mutual understanding. The peoples must learn what these can teach. UNESCO is commissioned to foster among all the peoples the knowledge that makes for understanding. It is bidden to use all its powers and all its endeavors to promote this end. In doing so it faces two series of obstacles. One is the networks of prejudice that block the road of social knowledge. The other is the bars of many kinds that present intercommunication between group and group, between nation and nation, shutting off the opportunity to learn and sometimes forbidding even the right to listen or to read. The preamble of the Constitution of UNESCO proclaims that education of humanity is a sacred duty of all the nations. For UNESCO the fulfillment of that sacred duty becomes the permanent agendum.

PROBLEMS OF INTERNATIONAL UNDERSTANDING

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(Read April 19, 1946, in the Symposium on UNESCO and American Participation in its Activities)

IT is the theme of the present paper that misunderstanding of one another and one another's ways of life by the peoples of the world has been a major cause of war, and that such understanding of one another as can be achieved through the humanistic and kindred social disciplines can go far to avert war and to maintain peace.

By ways of life we here mean all that is thought or wished or done by a given people: its work and play; its language, literature, and fine arts; its science, wisdom, and philosophy; its domestic, economic, and political institutions and life; its standards of courtesy and etiquette; its moral code and practices; its religion; its value systems; the internal ideals and incentives and the external controls and forces that keep the whole social organism going.

By the humanistic and kindred social disciplines we mean those which concern themselves with peoples' ways of life. No sharp line divides humanistic from social studies. They interweave and overlap at almost every point. To separate them by definition is a hopeless Shylock task. For brevity's sake in the present paper we shall refer to them jointly as the cultural disciplines.

By peace we mean not merely its negative aspect, the absence of armed conflict between nations. We have also in mind its positive aspect, peaceful friendly cooperative relations between independent major and minor powers and between such powers and their dependencies.

The technological advances of recent decades, especially in the fields of transportation and communication, as well as contemporary economic, political, and military developments, have brought the peoples of the world into markedly closer contact with one another than ever they have been before. That such contacts will become increasingly closer in the years immediately ahead can be confidently predicted. We, the nations and peoples of the world, the major powers and the minor independent and dependent commonwealths, shall have to live together at closer and closer quarters in a smaller and smaller world. It goes without saying that we want to live together harmoniously. However the few may feel, the many are weary of war. We want no more of it. We want peace.

Without contact there can be neither friendly cooperation nor unfriendly competition. With multiplying contacts come both increasing opportunities and need for peaceful living and working together and increasing hazards of armed and unarmed conflict. Will the more intimate contacts that are upon us and that lie ahead draw and impel the peoples of the earth toward greater pan-human friendliness and harmony, or toward more acute international unfriendliness and tension?

Wars are not inevitable. They are not part of human heredity as such. There are no war genes. While war has been a common phenomenon in the history of most nations and peoples, many have cleaved consistently to the ways of peace. Nations and peoples themselves choose. To paraphrase Elihu Root's formulation: no issue is so grave but can be settled peacefully if the nations concerned really wish peace; none so trivial but can be made a cause for war if the nations concerned really wish war. Nearly the same thought is expressed in the opening words of the preamble to the Constitution of UNESCO: "Since wars begin in the minds of men, it is in the minds of men that the defences of peace must be constructed." The two chief things that must be in the minds of men if friendly cooperation instead of war is to prevail are mutual good will and mutual understanding.

We shall take up each of these in turn and ask what the cultural disciplines can do to foster them.

First, good will. We may begin by listing some of the main things in the minds of men that engender international ill will and so lead to war. An exaggerated nationalism may mean such narrow attachment to our own national interests as to bar broad concern for the interests of other peoples. Chauvinism may develop at the expense of international pan-human solidarity. Outsiders resent such narrow clannishness and selfishness. A people may become so enamored of its own mental and moral graces as to look upon all other peoples

as inferior. But other peoples are sensitive; they may resent such assumptions often even more deeply than they resent economic or political exploitation. Members of one national or cultural group are apt to look upon themselves and their own ways as normal, sensible, rational; upon other peoples and their ways as strange, odd, queer, uncouth, outlandish, ridiculous. Other peoples resent such characterization. Nations and members of national groups commonly live by a double ethical code, one code of justice and fair play toward their own group and its members, another less equitable code or no code at all toward foreign nations and individual foreigners. Foreigners resent such selfish disregard of their rights.

If we want international good will in place of ill will, peace in place of war, so far as possible we shall have to replace narrow chauvinism with liberal pan-humanism; assumptions of superiority and inferiority with recognition of essential equality; ridicule of the supposedly queer with insight into basic normality and identity; practice of the deadly double ethical code with acceptance of a single ideal of equal justice and fair play to all humankind.

It is obvious that not all this formidable task of replacing international ill will with international good will can be accomplished by intellectual processes, with the sole aid of such knowledge as the cultural disciplines can discover and diffuse. To know all is, as the French proverb runs, to forgive all. Much, however, of international ill will stems, not from ignorance, but from conflict of interests. Each nation aspires to its place in the sun, a modest or ambitious one as the case may be. Each desires its due measure—commonly more than its due measure—of prestige, of economic advantage, of political power. Each partly attains its desires, but each fails in part to attain them. From failure arise frustration, insecurity, hatred, in the familiar sequence. Much, the greater portion perhaps, of international ill will is a disease traceable to other causes than ignorance. Knowledge alone, however full, cannot effect the cure. Religious and ethical forces must play their whole part. Inspirational and normative resources must be unremittingly tapped. Nevertheless, the cultural disciplines can and do render invaluable service in the cause of good will.

First, such acquaintance with other peoples and their ways of life as is provided by the cultural disciplines will almost inevitably breed a decent respect for these peoples themselves and for their ways of life. Acquaintance with the people themselves reveals them to us in all their humanity, far indeed from perfect and unblemished, but averaging fair; not queer and strange and uncouth, but very much like ourselves, with the same loves and hatreds, the same higher aspirations and poignant anxieties, the same affections and sorrows, the same alternations of generous and ungenerous impulses. On all levels of technological advance, from the simplest hunting economy to the great urban civilizations, this humanity of ours, with all its nobilities and ignobilities, the world over, beneath skin-deep differences, is astonishingly identical.

Second, exposure to acquaintance with other peoples' ways of life will usually beget both an honest appreciation of the intelligence underlying them and a salutary humility regarding the achievements of our own civilization. No doubt in science and technology we are far in the lead. But of our management of our own lives and of our society we can hardly afford to boast too loudly. Our increasing insight into the philosophy and arts and literature, into the social, legal, and political institutions of the great Oriental civilizations is giving us a new and deeper appreciation of their superb achievements. And even in the humbler cultures of the non-literate peoples we are perceiving marked indications of social inventiveness and are recognizing highly intelligent and democratic adaptations that bring about reasonable approximations to the goals of human security and happiness.

Third, such decent respect for other peoples and for their cultures can and readily does lead to respect for their rights and to concern for their well-being. It helps us to see them as human beings very much like ourselves, as honorable members of the great human family, worthy carriers of our common human inheritance, intelligent partners in our common human enterprise.

For harmonious living and cooperative working with others, good will is imperative. But understanding is equally so. Friendship between peoples, like friendship between individuals, demands mutual understanding. Where there is lack of understanding friendship cannot grow. Where there is misunderstanding, friendship wilts and dies.

If we wish to live today and tomorrow in peace with the peoples beyond our national borders, we are under the critical necessity of achieving deep and intimate understanding of these peoples and of their ways, and incidentally under the same critical necessity of achieving a deeper and more

objective understanding of our own selves and of our own ways. The great diaspora of European culture that began with the Portuguese and Spanish explorations in the second half of the fifteenth century ushered in nearly five centuries of exploitation by European peoples of the other peoples of the world. This long period of exploitation is rapidly coming to an end. The more rapidly the end comes, the better it will be for all of us. The Far and Middle and Near East are entering upon a second youth. Eastern Europe has thrown off the tutelage of Western Europe and is standing up in the vigor of its full manhood. Latin America is awakening to a new maturity. Africa is coming of age. Whether we will it or not, and most of us will it, we shall have to reckon with all these peoples and nations as equal associates in the parliament of man. We shall have to live closely with them, and as equals in a pan-human democracy.

This means that we shall have to know them. We shall need intimate knowledge of all their ways of life from their work and play to their philosophy and religion. Particularly we shall have to understand the things that are not matters of direct observation,—the intangible things, the value systems, the desires and ambitions, the incentives and motives, the attitudes and preferences, the prejudices and dislikes, that underlie their social systems and culture as well as those that underlie our own. We shall have to know much more about the moral and social codes of the peoples of the world, the varying concepts of rights and claims as well as the basic uniformities common to all codes. We shall have to get a better grasp of what democracy means among these various peoples of the world, and of the still more fundamental concept on which that of democracy itself rests, the concept of the worth of human personality. In all these things we shall need to know the common denominators as well as the specific differences from people to people. We shall need to know the common denominators in order that we may work out a common basis of friendly cooperation. We shall need to know the specific differences in order to move intelligently towards mutual adjustment and equitable compromise.

These are the peoples we need to know and these are some of the more important things we need to know about them. Not that other things are unimportant. Indeed there is hardly a fact, however insignificant it may seem, about other groups or peoples, and for that matter about ourselves, knowledge or ignorance of which at one point of contact or another may not turn out to be of crucial importance. The issue even of peace or war can conceivably turn on knowledge or ignorance of what may seem to us at first blush minutiae of etiquette or linguistic expression.

Of what we should know, how much do we actually know? At the beginning of World War II we were made to realize keenly that we were caught with only meager fragments of the factual knowledge we needed about so many peoples of the world, this in spite of the vast amount of research that had been done by the cultural disciplines and in spite of our great library collections on peoples of both the Old World and the New, including our own selves. All in all, the overwhelming majority of our workers in the cultural disciplines had confined their attention chiefly to the Occidental peoples, and even here to the Occidental peoples of Western Europe and North America. Our traditional provincialism, for the rest quite understandable, must perforce give way to a pan-human scholarly interest.

To bridge the chasm that yawns between what we should know and what we do know we shall need notable expansion in the cultural disciplines —notable expansion in professional personnel, in research, and in support. The type of knowledge we need cannot be gathered from travellers' tales, from sketchy impressionistic jottings by irresponsible or casual observers, however high their integrity. Many of the facts we need lie loose on the surface and can be easily gathered. But a great many of these facts lie deep beneath the surface. They can be discovered only through systematic research carried out on the highest levels of scholarship and with the most cautious and penetrating scientific insight. In the fields we have in mind it is better to have fewer facts than to have so many that are not so.

The facts and interpretations to be gathered through scientific and scholarly research must not be left hidden in institutional archives nor allowed to gather dust upon library shelves. First of all they must be placed at the disposal, and specifically brought to the attention, of governmental, commercial, educational, missionary, and other bodies in immediate contact with other peoples and other cultures. Second, this knowledge must be widely diffused among the masses of the people, through the schools from the lower grades to the universities, and through the ordinary media of adult education, if an informed and intelligent

public opinion is to be created and if international policies that make against war and for peace are to prevail. And it is the strong conviction of the present speaker that we who are professionally engaged in the cultural disciplines must not wait for the mountain to come to us. We must go to the mountain.

The task ahead of averting war and maintaining peace, insofar as its fulfillment lies with the cultural disciplines, is enormously complex and difficult. There is, however, a very hopeful side to it. These very disciplines have made it abundantly clear that war is not part of human nature as such, not a matter of human heredity. War can be averted. One proof is the fact that it has been fairly well averted by many cultures. A further hopeful note is added by our newer knowledge of the extreme plasticity of human personality under varying social and cultural influences. The task ahead is an arduous one. But it can be done.

ANALYSIS OF SOME PHYLOGENETIC TERMS, WITH ATTEMPTS AT REDEFINITION

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ABSTRACT

The terms homology (homogeny), analogy, homoplasy, divergence, parallelism, convergence, homeomorphy, time signatures, homeomorphic recurrence, and iteration are traced back to their origins and critically analyzed.

The following conclusions are arrived at:

Owen's (special) homology should be restricted to similarities between parts, organs, or structures of different organisms attributable to common ancestry; homogeny (Lankester) then becomes a synonym of homology.

Homoplasy (Lankester) brings about similarities between organisms or their parts, organs or structures, due not to common ancestry, but to independent acquisition of the similar characters. Even where this independent acquisition may be attributed to some latent or potential predisposition inherited by both or all lines concerned from a common ancestor (Osborn's latent or potential homology), the similarities should be considered homoplastic but not homologous. Heterology (Cope), homomorphy (Palmén), isomorphism or isomorphy (Parker, Fürbringer), homeogenesis (Eimer), and morphological equivalents (Hyatt) are considered synonyms, analogous variations (Darwin) and independent homologies (Hubb) are considered special cases of homoplasy.

Other special cases of homoplasy are convergence and parallelism, distinction between which should be based on whether or not similarity increases with evolution rather than on degree of relationship between the lines involved.

Convergence may lead to homeomorphy. The latter term ought to be restricted to similarities affecting the whole outer appearance of the homeomorphs and reaching such a degree that the one may be mistaken for the other even by a trained naturalist, unless certain internal or obscure characters are examined. Homeomorphy is not equivalent to, nor does it include mimicry, but the two concepts overlap.

Neither homoplasy, nor parallelism, nor convergence and homeomorphy imply anything as to contemporaneity of the similar changes; all these phenomena may be either heterochronous or isochronous.

Isochronous convergence and homeomorphy may, taxonomically, lead to polyphyletic morphological genera and even higher units.

Dacqué's terms "Zeitformenbildung" and "Zeitbaustile" are rejected, his "Zeitsignaturen" (time signatures) are admitted as a descriptive, not explanatory, term to designate certain cases of isochronous parallelism or convergence.

Recurrence of morphologic types may be merely homeomorphic recurrence or attributable to Koken's "iterative Artenbildung" (iterative formation of species = Beurlen's iteration).

In addition to the terms mentioned above, many others are discussed or mentioned. All phylogenetic terms used are indexed.

INTRODUCTION

THIS paper has grown out of a study undertaken a few years ago by one of its authors

(Haas), stimulated by a paper by Cloud (1941). This first study by Haas was later discussed with Simpson and it was decided to expand its scope and to modify it somewhat. While the expanded study was in preparation, discussions of homology and analogy were published by Boyden (1943) and by Hubbs (1944). Their views were discussed in correspondence by Boyden, Hubbs, and Simpson, and in conversation by Boyden, Haas, and Simpson. Boyden also kindly made available to Haas and Simpson some written but (at present) unpublished remarks on this subject.

Our study is different in scope and in point of view from those by Boyden and by Hubbs and it reaches somewhat different conclusions on certain of the points that have been treated by all of us. It therefore seemed advisable to complete and to publish the work originally undertaken by Haas, with further modification in the light of this wider discussion. Except for the first two paragraphs of this introduction, three notes explicitly stated to be by Simpson, the discussion on the genetic basis of the phenomenon usually called parallelism (p. 336), and a few very brief passages elsewhere, the words of the present paper have been written by Haas who also performed the extensive literary search involved. The whole study has, however, been repeatedly discussed with Simpson, and Haas and Simpson are in agreement as to almost all the opinions here expressed. At Haas' request, Simpson is associated with him as co-author in the sense that he shares responsibility for the conclusions reached, rather than in the sense that he has shared equally in the basic research or in the actual writing of this paper. There remain two minor points regarding which our detailed opinions are not precisely the same, but these have no important bearing on the general conclusions reached. On each of these points the main text has been left as written by Haas and a note by Simpson has been added.

The authors' interest has been focused primarily on the hitherto rather ambiguously and indiscriminately used terms parallelism, convergence, and homeomorphy. Homoplasy had to be included since it turned out to be the higher category under which come both parallelism and convergence. Thus homology, from which concept homoplasy had once been split, came into play, drawing along its old counterpart analogy. Moreover, many other terms have had to be discussed, or at least mentioned, mostly for the sake of distinguishing them from the terms on which attention is mainly focused. Since discussion and mention of these less important terms have had to be scattered throughout the paper, as occasion arose, it has seemed desirable to append an alphabetic index of all the phylogenetic terms involved in this study.

Throughout the investigation, it is first attempted to trace the terms under discussion back to their origin, not because of some conception of priority which would here be out of place, but because insight into the original usage of an expression is believed to be helpful for its proper understanding. Then, the further evolution of the concept is followed as far as seems to be worth while, a critical analysis is attempted, and, where it seems necessary, amended definitions are proposed. Finally synonyms of the terms studied, where such exist, are listed. The clarification of phylogenetic terminology by eliminating a host of synonyms or obsolete or otherwise superfluous terms may be considered one of the purposes of this study.

HOMOLOGY (HOMOGENY), ANALOGY, HOMOPLASY

ORIGIN AND HISTORY

(*a*) *Homology, as Conceived by Owen*

Tait (1928: 153), believes the geometrical meaning of this term to be the original one, corresponding members of similar figures being "homologous." Thus it represents to him a one-word condensation of Geoffroy St. Hilaire's "principle of connexions." It may, however, be doubted whether Owen, when defining (1843: 379) "homologue" as "The same organ in different animals under every variety of form and function," had this geometrical meaning in mind.[1]

Soon afterwards, this term was to undergo a considerable amount of amplification on the one hand and subdivision on the other. In 1846 Owen (1847: 175–176) distinguished three kinds of homology: "The first is that above defined, viz. the correspondency of a part or organ, determined by its relative position and connections, with a part or organ in a different animal; the determination of which homology indicates that such animals are constructed on a common type. . . . " This is Owen's *special homology*. It will be noticed at once that in the first place

[1] Owen (1866: XII) himself points out that "Prior to 1843 the term [homologues] had been in use, but vaguely or wrongly," and quotes a passage from Geoffroy St. Hilaire (1825) in which "homologues" and "analogues" are used in closely related senses.

considerations of topographic and comparative anatomy are made decisive for this kind of homology, although mention of homologues as being "constructed on a common type" may imply a slight foreboding of common origin. "A higher relation of homology" is defined by Owen (*loc. cit.*) as "That in which a part or series of parts stands to the fundamental or general type;" this is termed by him *general homology*. Thus the correspondence of the basilar process of the human occipital bone with the basi-occipitale of a fish or crocodile is cited as an example of special homology, but the character of that process as the "centrum" or "body of the last cranial vertebra" as one of general homology. Finally, *serial homology* is defined as the serial repetition or representative relation in the segments of the same skeleton, and these serially related or repeated parts are called "homotypes."[2] This division and distinction are repeated without any essential change by Owen, 1866 (pp. XII, XIII).

As can be readily seen from this scheme, both general and serial homology, as there defined, are phenomena which do not presuppose two or more organisms to be compared with each other and, therefore, lie outside the original scope of homology, as conceived by Owen in 1843. Thus they may well be eliminated from the further course of this investigation, as may other terms proposed by later authors for categories of "homology" apart from special homology.[3] Following, in this respect, Boyden's (1943: 233) proposal, and contrary to Hubbs (1944: 293), the term homology is hereinafter used within the restrictions, though not with the definition, of Owen, 1843, i. e. as equivalent to his special homology of 1847. This seems to be in accordance with most contemporary usage, and we have dispensed with adding "*s. str.*" or the like to this term to indicate that it is not meant to include Owen's general and serial homologies. The two latter terms may serve a useful purpose in comparative anatomy and genetics (*cf.* Boyden, 1943: 234), but it is questioned whether they have any "raison d'être" in the realm of phylogeny.

(*b*) *Analogy*

The history of this term before Owen has been traced back as far as to Aristotle by Boyden (1943: 231–232), but Owen's definition of 1843 (p. 374) may here be chosen as point of departure: "Analogue. A part or organ in one animal which has the same function as another part or organ in a different animal." Owen himself seems later to have noticed that the word "another" is disturbing in this definition because, when repeating it in 1866 (p. XII), he replaced the last eight words by "a part or organ in another animal."

(*c*) *Homogeny, Homoplasy*

After the advent of evolutionary ideas—all but ridiculed by Owen as late as 1866 (p. XXXVI)[4]—Owens' concept of homology proved no longer quite satisfactory, lacking, as it did, any phylogenetic implications. It was this need for harmonizing Owen's pre-evolutionary term with the new school of thought that convinced Lankester (1870*a*: 36) of the necessity "to have two terms in place of the one 'homologue,' and to broadly distinguish the nature of the resemblances to which they are applied." Thus he proposed to call "structures which are genetically related, in so far as they have a single representative in a common ancestor," homogenous and the relation between them homogeny, and to "speak of one as the homogen of the other."

In the passage just quoted, Lankester clearly started out to establish a dichotomous distinction but he muddled the subject immediately afterwards in answering his own question (*ibid.*, 38): "What is the other quantity covered by the term homology over and above homogeny?" Instead of clearly defining the other limb of his dichotomy, as he had the one, he gave a wordy and by no means unequivocal explanation of what he had in mind.[5, 5a] He made things even

[2] Gegenbaur (1898: 23), however, within the scope of his "Allgemeine Homologie," which is not equivalent to Owen's general homology, calls symmetry across the median line homotypy. The term homodynamy is used by Gegenbaur to cover both Owen's general and, at least in part, serial homology.

[3] This applies to Gegenbaur's (1898: 23) elaborate scheme as well as to many of the 25 different categories distinguished by Mivart (1870: 118–119), only some of which come within the scope of Owen's special homology.

[4] ". . . the hypothetical state exemplified by the guess endeavours of Lamarck, Darwin, Wallace, and others."

[5] "When identical or nearly similar forces, or environments, act on two or more parts of an organism which are exactly or nearly alike, the resulting modifications of the various parts will be exactly or nearly alike. Further, if instead of similar parts in the same organism, we suppose the same forces to act on parts in two organisms, which parts are exactly or nearly alike and sometimes homogenetic, the resulting correspondences called forth in the several parts in the two organisms will be nearly or exactly alike. There will be, I imagine, no kind of difficulty to the evolu-

worse by including and even choosing his examples from serial homology, and he concluded by proposing "to call this kind of agreement homoplasis or homoplasy" (*loc. cit.*). Lankester's words "which parts are exactly or nearly alike and *sometimes* homogenetic" (italics ours) clearly indicate that homogeny was to him not an essential prerequisite of homoplasy. The same holds true for his further attempts (*ibid.*, 42) at defining homoplasy as "depending on a common action of evoking causes or moulding environment on such homogenous parts, *or on parts which for other reasons offer a likeness of material to begin with*" (italics ours). Nevertheless, his altogether obscure presentation misled Osborn (1902*a*: 261) into the belief that "homoplasy always involves homology, while parallelism and convergence may or may not involve homology" and to publish a chart of "Analogy in Evolution" in which homoplasy was considered a phenomenon distinct from both parallelism and convergence.[6] However, in a letter published by Osborn in 1907 (1907*a*: 238–239), Lankester "demurred from Osborn's interpretation of his definition of 'homoplasy,'" stating that "Homoplasy does *not* demand an element of homology" and that he "recognized (as hitherto combined under one term 'homology') *only* homogeny—or hereditary quality—and homoplasy or moulded non-heredity quality." The "likeness of material to begin with" of 1870 (see above), alluded to in Osborn's paper 1902*a*, is now explained by Lankester as "*either* a likeness of true homogeny (that is of form and relation inherited) *or* a likeness of similarity in material, in position, or in initial form—not due to close homogeny—but possibly a likeness of such a general character as the 'likeness of material' (not of elaborated form and parts) in two epidermal surfaces."[7] Thereupon Osborn (1907*a*: 228) concluded that "Lankester's *homoplasy is equivalent to analogous evolution, to parallelism, or convergence.*" Two years earlier, Osborn (1905: 959) had already included parallel and convergent adaptations in the analogous ones, stating: "To these processes and results of similar modeling Lankester has applied the fitting terms homoplasy and homoplastic."[8]

(*d*) *The Modern Meaning of Homology*[9]

When splitting Owen's concept of homology into homogeny and homoplasy, Lankester (1870*a*) clearly intended to replace homology by the one concept or the other, as the case might be, and explicitly stated as his "reason for not retaining 'homology'" that "It is less likely to cause confusion if we have a new term than if we amend an old one."

Strangely enough, just what Lankester wanted to avoid turned out to be the result of the further evolution of this terminological problem: "Homology" did not disappear, as was his intention, nor, in those cases where it is equivalent to Lankester's "homogeny," was it replaced by the latter term which never succeeded in becoming generally or even widely adopted. Instead, "homology" quite gradually assumed the connotation that "homogeny" was intended by Lankester to convey. It is true that Bourne as late as 1910 (p. 38) complained not only that "the term homogeny has not been so generally accepted, and many, if not most zoologists have preferred to retain the old word homology," but also that "in so doing . . . many of them have failed to distinguish between the two quantities

tionist or student of Mr. Herbert Spencer's writings in admitting the above propositions; and it is in accordance with the principle they set forth that serial homologies and much else which, together with what is here distinguished as homogeny, has been included under homology may be explained" (*ibid.*, 39).

[6a] This lack of clarity in Lankester's explanations seems to have contributed to some misunderstandings of the concept "homoplasy" by Spemann (1915: 79, 82), heavily attacked by Söderström (1925).

[6] Still earlier (1900: 564) Osborn had spoken of "the law of parallelism or homoplasy" without any differentiation between these two concepts (*cf.* Osborn, 1902*b*: 356, footnote).

[7] Tait (1928: 159, 160) seems inclined to assume that Lankester somewhat extended the scope of this term homoplasy in his later life, but it may well be that he had all this in mind at the very outset but failed to express it with sufficient clarity. In his letter, quoted above, he seems to take the position that he is merely interpreting his paper of 1870. This position seems to be supported by his reply to Mivart (1870*b*), where he endeavors to make a clearer distinction between homogeny and homoplasy than in his essay, but also by the following sentence of the essay itself (1870*a*: 41): "Homoplasy includes all cases of close resemblance of form which are not traceable to homogeny, all *details* of agreement not homogenous, in structures which are broadly homogenous, as well as in structures having no generic affinity."

[8] Obviously without knowledge of these later utterances of Osborn's, Bourne (1910: 39) found difficulty in differentiating between Osborn's categories (of 1902) and pointed out (*ibid.*, 40): ". . . Lankester's term homoplasy, covers all the cases." Similarly, Willey (1911: X-XII), when questioning Osborn's scheme of 1902, was unaware of the latter's change of opinion that had taken place in the meantime.

[9] For excellent presentations of the change of meaning undergone by this term after the advent of Darwinism see Spemann, 1915: 68–72, and Tait, 1928: 156–158.

[?] contained within the single term, of which the differences were so clearly pointed out in Lankester's essay [of 1870]."

However, in the meantime the term homology had begun to go a long way to replace the one of its intended replacers. It had been started in this direction, even a few years before Lankester's publication, by Owen, himself, who admitted (1866: XXXVI) that, "The most intelligible idea of homologous parts in such series is that they are due to inheritance." About the end of the nineteenth century Gegenbaur (1898: 22) emphasized that "homology is governed by descent; homologous organs are of common origin"[10] (translation from the German), and Osborn concluded his paper of 1902*a* (p. 270) with this sentence: "The only decisive test of homology is historic community of derivation (i. e., homogeny)." This conception seems to have been rather generally accepted about fifteen years later, when Dendy in his glossary (1923: XXVII) defined homology as "essential structural identity due to community of descent." Thus even Boyden—who later (1943) advocated the return to Owen's original meanings of homology and analogy—admits in an earlier paper (1935: 448): "It is generally agreed . . . that homology is due to community of descent." Quite recently Hubbs (1944: 290) summarized this development as follows: "Homology has thus come to signify an agreement in evolutionary derivation. . . . The ideas of homology and community or origin have become intimately associated, almost to the point of synonymy."

It must not be overlooked, however, that some students still adhere to the opposite belief. Thus Kälin (1946: 136–137) quite recently pleaded for the morphologic conception of homology as opposed to the phylogenetic one, quoting Hertwig (1906) for his point of view. Thus he joins, though unconsciously, Boyden (1943) in the battle cry "Back to Owen [1843]."

Spemann (1915: 81), on the other hand, advocated still another terminology that would—against Lankester's intention—retain homology as a neutral term, with homogeny and homoplasy, both understood as originally defined by that author, as subdivisions.

Not only because we have to agree with the historical fact that Lankester's term homogeny has gradually been relegated to mere synonymy with homology, part of which concept it was intended to replace, but also for the objective reasons expressed below, "homology" is used, in this paper too, with the meaning Lankester gave his term "homogeny."

[10] When studying Gegenbaur's work, Osborn made a note to p. 24: "Special homology—equals the 'homogeny' of Lankester."

DEFINITIONS AND DISTINCTIONS

(*a*) *Homology*

Thus homology (Owen, 1843, = special homology, Owen, 1847) is here defined as a similarity between parts, organs, or structures of different organisms, attributable to common ancestry.

It will be noticed that—despite Hubb's (1944: 292) advocating "that we think and write of homologous functions in the same way that homologous structures have been treated"—functions are not included, in the above definition, in the enumeration of similar categories. It is believed that the function of organs may or may not be the same in different organisms, but that functions *as such* are never homologous the one to the other. What Hubbs really seems to have in mind is to use, in certain cases, identity of function as a criterion of homology (*ibid.*, 291). There is certainly no objection against this, but it must be kept in mind that identity of function has been considered, from the very beginning of the terminology under discussion, to be *the* characteristic of analogy rather than homology.

Note by Simpson: The preceding paragraph represents the view of Haas. I do not quite agree, although the disagreement is of very slight importance and is in part merely a matter of verbal expression. Hubb's point was to stress the difficulty and, at times, the undesirability of considering structure and function separately. Similarity of function is not exclusively characteristic of analogy. It is often, indeed usually, characteristic of homology, also. In fact, from one point of view, analogy and homology are two alternative theoretical explanations of similarity both in function and in structure. In such cases, I can see no objection to speaking of homologous functions, as an expression of opinion as to the origin of a dynamic complex including the functions along with the structures performing them. That "functions *as such* are never homologous the one to the other" is a matter of definition, only. I agree that such a definition is desirable if phrased that functions, considered as abstractions and without consideration for the structures that perform these functions, should not be spoken of as homologous, but that homology frequently involves both function and structure and in this combined sense it is proper to speak of the homologous functions performed by homologous structures. It is also

true, but less common, that the functions of homologous structures may not be homologous.

Moment's (1945) recent proposals to lump special, serial, and general homologies and even to discard the term homology altogether, replacing it by the all too neutral "similarity," are decidedly rejected. Homology, as here understood, is still a well usable phylogenetic term. Particularly unfortunate and, were it to be accepted, bound greatly to increase the prevailing terminological confusion is Moment's further proposal of no fewer than six "new" terms for the distinction of various kinds of similarities, most of which are preoccupied, often with a different meaning, in the previous literature on the subject.[11]

(*b*) *Analogy* vs. *Homoplasy*

Before attempting definitions of either analogy or homoplasy or both, it will have to be examined whether or not these two terms are synonymous. This question has vexed students ever since homoplasy, the younger term, was proposed in 1870. Lankester, himself, (1870*a*: 40–41) answered the question as follows:

> It may be said that the term "analogy," already in use, is sufficient to indicate what is here termed "homoplasy"; but analogy has a wider signification given to it in which it is found very useful to employ it, and it could not be used with any accuracy in place of homoplasy. *Any* two organs having the same function are analogous, whether closely resembling each other in their structure and relation to other parts or not; and it is well to retain the word in that wide sense.

Dendy (1923), although giving in his Glossary (pp. XVIII and XXVII, respectively) different definitions for analogy[12] on the one hand and homoplasy[13] on the other, speaks (*ibid.*, 246) of "The terms homology and analogy (or homoplasy)" and describes (*ibid.*, 258) "analogous or homoplastic organs" indiscriminately.

Tait (1928: 159–160) explicitly discusses the above question, stating that "the various instances of analogy are just of [the] kind" of resemblances to which the term homoplasy is applicable, and elsewhere (*ibid.*, 168) also speaks of "homoplasis or analogy."

Hubbs (1944: 296) arrives at the conclusion that Lankester[14] "merely substituted 'homogeny' for special homology and 'homoplasy' for analogy." Thus he, too, equates homoplasy with analogy.

In our opinion, however, analogy and homoplasy are not synonyms.

If "analogy" is to retain, beyond its rather vague general significance, any technical meaning in comparative anatomy and phylogeny, it can be but the one implying function or use. This is the meaning given to this term by Owen (1843) and maintained in the biological sciences, though with certain qualifications, ever since. Even Hubbs (1944: 306) seems to agree with Boyden (1943) in considering "agreement *in use* [italics ours] of characters (structures or functions)" of distinct evolutionary origin as essential for "a modern concept of analogy."

If use or function is implied by the term analogy, then this term does not connote, as do both homology and homoplasy, a morphological resemblance (*cf.* Lankester, 1870*a*: 41). Theoretically at least, parts, organs, or structures of two or more organisms may serve the same use or have the same function without being similar. On the other hand, no meaning as to use or function is implied in the term homoplasy. It might be rather tempting to have to do with one dichotomy only: homology (similarity due to common ancestry)—analogy (similarity not due to common ancestry). However, after clarification of the concepts involved the need for such a simple dichotomy seems to be fulfilled better by the one contrasting homologous and homoplastic similarities, analogy being on a different categorical level from homology and homoplasy. Furthermore, homoplasy is, at least primarily, an evolutionary process bringing about homoplastic similarities, whereas analogy is from the outset a relation between two organisms or parts thereof.

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[11] Homodynamy (adjective: homodynamic) was used by Haeckel as an equivalent of Owen's homotypy (see Hubbs, 1944: 295) and homodynamic by Abel (1909: 227–230) in an evolutionary (functional) sense, not in an ontogenetic one, as it is by Moment. Homogenetic is used by Buckman (1895: 456) and others to indicate common origin, and both homogenetic and heterogenetic are so closely linked to homogeny (Lankester, 1870*a*) and heterogenesis, as used by Korschinsky, Fenton (1931: 74 ff.) and Dacqué (1935: 132), respectively, that they imply a phylogenetic significance, whereas Moment proposes them as genetical terms. Homophyletic was proposed, in the German version "homophyl," as early as 1884 (p. 17), by Palmén, accepted by Fürbringer (1888: 1122) and Haeckel, and is being used by Hubbs (1944: 305), as is its counterpart heterophyletic. As pointed out below, homophyly is here considered a synonym of homogeny and, therefore, of homology, as defined above.

[12] "Superficial resemblance due to similarity of function."

[13] "Secondary resemblance due to similarity of habit."

[14] Misspelled "Lancaster" throughout Hubbs' paper.

Thus, homology and analogy are not mutually exclusive, and Boyden's (1943: 231) examples of homologues which are at the same time analogous, or of non-homologues which are not analogous all the same, are still considered valid.

Note by Simpson: This involves the second of the points on which Haas and I are not in complete agreement, although, again, our disagreement is not fundamental and does not affect the more important conclusions such as the definitions of homology and homoplasy.

Homology, as we agree, is best defined as similarity interpreted as due to common ancestry. Homoplasy, as we also agree, is best defined as similarity (or as including *any* process leading to similarity) that is not explicitly interpreted as due to common ancestry. Both terms rather than being purely descriptive (as in Boyden's definition of homology, for instance) express an opinion, one positive and one negative. Homology expresses an opinion as to how the similarity arose. Homoplasy expresses an opinion as to how the similarity *did not* arise, i. e., that it did not arise by homology, but it does not express an opinion as to how the similarity *did* arise.

I do not, in quite the same way as Haas, see these as alternatives at the same categorical level. The set is not positive, "a" and "b" as mutually exclusive categories, but is a dichotomy of "a" and "not−a." Under "not−a" it is still possible to have a sequence of alternatives, such as "b," "c," etc., that are positive categories on the same level as "a." Quite clearly by a few authors and vaguely by many, "analogy" has been used as an alternative of type "b," although, as the quotations gathered by Haas show, it has often been used for "not−a" and hence as a synonym of homoplasy.

Haas and I agree that equation of analogy with homoplasy is undesirable, despite the considerable weight of usage, because it omits the element of function, which historically belongs in the concept of analogy and which still tinges, at least, that concept in the minds of most users of the term. I feel, however, that similarity in structure along with similarity in function is equally an essential part of the concept of analogy, as that term has almost always been used. Moreover, the implication is usually present to some degree and it has sometimes been explicitly stated that the structural similarity here in question is not due to homology but is correlated with community of function as opposed to community of ancestry. It is in this sense that analogy is a true alternative (but not the only alternative) to homology as a positive category on the same level, a "b" category rather than a "not−a" category or something on a different level altogether. That is, analogy, when used in this way, expresses a positive opinion, or theory, that a structural resemblance is correlated with function, just as homology expresses the view that it is correlated with common ancestry.

Unlike homoplasy, analogy offers an alternative theory as to the basis of the resemblance in question. It is in one way a subdivision of homoplasy, designating, like homoplasy, a similarity that *is not* interpreted as homology but adding to this purely negative definition of homoplasy the opinion that the similarity *is* to be interpreted in another way. Although parallelism and convergence may also correctly be called subdivisions of homoplasy, this does not place them on a level with analogy. They belong in a different categorical system because they are (as here defined) descriptive only, while analogy and homoplasy, itself (but only negatively), are interpretive.

(*c*) *Analogy*

Analogy is thus here defined as the relation between parts, organs, or structures of different organisms which serve the same use or have the same function.[15]

(*d*) *Homoplasy*

Homoplasy, on the other hand, may be defined to comprise all evolutionary processes bringing about similarities between organisms or their parts, organs or structures, which are not due to common ancestry, but to independent acquisition of the similar characters. Although homoplasy, if translated literally, indicates primarily a process, the term has, since Lankester (1870*a*), equally been applied to the similarities produced by this process, i. e. to the relation prevailing between the similar organisms or homoplasts.[16] Homoplasy thus includes both parallelism and convergence, to be dealt with under the next heading. This might raise the question whether the term homoplasy might not be dispensed with altogether, the two others being well established and even better known and, as it seems, at least hitherto more frequently used than homoplasy. However, it seems advisable to retain the last term as the more comprehensive one all the same, all the more so since the boundaries between parallelism and convergence are quite indefinite and it is frequently difficult to decide which of these special terms applies (*cf.* below, pp. 333 ff.).

Independent acquisition of the similar characters in both or all lineages concerned is thus a characteristic of homoplasy as well as of parallelism and convergence. It may be added right here that this essential criterion seems to have

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[15] See preceding note by Simpson.

[16] The same shift in meaning will be encountered in the terms parallelism and convergence, also primarily indicating processes rather than relations.

been recognized first by Darwin in a later[17] edition of his *Origin of Species* (1909, II: 221). There, in discussing his "analogical variations" (considered a special case of homoplasy below), he spoke of "the acquirement through natural selection of parts or organs, strikingly like each other, independently of their direct inheritance from a common progenitor."

The same thought, though expressed in other words, may be found in Cope's (1877: 343) sentence: "From these and many analogous cases, the general law may be deduced that identical modifications of structure, constituting evolution of types, have supervened on distinct lines of descent." There cannot be any doubt that what Cope here describes, apparently without knowing Lankester's 1870 paper, is homoplasy[18] or, more specifically, parallelism.

Scott, when discussing parallelism and convergence in his "Observations on the Modes and Factors of Evolution in the Mammalia" (1891: 364 ff.), repeatedly emphasizes the independent acquisition of the similar features by the convergent or parallel lines, as he does, a few years later (1896: 56), in his definitions of parallelism and convergence.

Similarly, Buckman (1901: 232, 238), in discussing parallelism and homeomorphy, defines the former as "the tendency of different genetic stocks to pass, quite independently, through similar phases of development" and points out that two lineages of terebratulids "develop similar multiplication . . . quite independently."

Homoplasy as well as its special cases parallelism and convergence do not imply anything as to contemporaneity of the similar changes in the two or more lineages concerned. For distinction between homoplasy, parallelism, and convergence in more or less contemporaneous forms on the one hand and in non-contemporaneous ones on the other, reference is made to a following heading.

By way of appendix, Tait's 1928 (p. 171) concept of phylogenetic plasis may here briefly be mentioned; without properly defining it, Tait recognizes in it "Three or four elements, [viz.] (1) the power to transmit by heredity the temporarily existing condition of structure; (2) adaptive modification of existing structure; (3) the invention of new structures; to which [may be added], whether an independent thing or not, (4) the occasional dropping of existing characters." Later (*ibid.*, 172) Tait deals with plasis as with a synonym of adaptation. Anyway, Tait's term seems to have been intended as the higher category including homoplasy, but it does not seem to have met with wide acceptance.

(*e*) *Homology* vs. *Homoplasy*

Distinction of homologous and homoplastic similarities is not always easy and is rendered the more difficult by the assumption, recurring again and again in literature, of some inherited latent or potential predisposition of more or less closely related groups to undergo the same or similar evolutionary modifications independently of each other.

On this very assumption Osborn (1902*a*, especially p. 268) based his "law[19] of latent or potential homology," involved in homoplasy.

Quite recently Simpson (1945: 9) suggested a genetical mechanism for some manifestations of this phenomenon, stating: "Homologous genes tend to mutate in the same way." Of course this suggestion is not new. Indeed, the first to make it seems to have been Darwin who, when explaining his "analogous variations" in the example of the pigeon (1860: 143–144), expressed the firm belief "that all such analogous variations are due to the several races of the pigeon having inherited from a common parent the same constitution and tendency to variation, when acted on by similar unknown influences." Dealing with the same subject in a later edition of the *Origin of Species* (see footnote 17), he wrote (1909, vol. II: 221):

> . . . the members of the same class, although only distantly allied, have inherited so much in common in their constitution, that they are apt to vary under similar exciting causes in a similar manner; and this would obviously aid in the acquirement through natural selection of parts or organs, strikingly like

[17] The edition which was the first to contain this paragraph is not available; by inference it must have been the fourth (1866) or the fifth (1869); the following quotations are from the American edition of 1909.

[18] The same holds true for Zittel's (1895: 14) attempt to explain convergence: ". . . Since the same causes produce the same effects not only in the inanimate world, but in organisms as well, similar formations of organs recur indeed in very different animals and plants if they have been exposed to the same outer influences, especially to the same mechanical actions." (Translation from the German.)

[19] Like many of his contemporaries, Osborn lavishly used the word "laws" where we would prefer the word "phenomena" or, at most, "principles." Eimer's (1898: 26–28) eleven "and other laws"—most of which are merely observed facts—might be cited as a particularly unmitigated case of this law-making tendency of that period.

each other, independently of their direct inheritance from a common progenitor.

A similar thought is expressed by Fürbringer (1888: 1122), according to whom "a morphological similarity of a higher degree (isomorphy)[20] pre-supposes in most of the cases that the genealogical discrepancy between the animals be not too wide. Absolutely heterogenetic animals rarely attain perfect isomorphy (at least in the vertebrate phylum)." (Translation from the German.)

Scott (1896: 58) declares "the statement [that numerous and close resemblances of structure are *prima facie* evidences of relationship to be] true, even though the resemblances have been independently acquired, . . . because the more nearly related any two organisms are, the more likely are they to undergo similar modifications."

Osborn, after his paper of 1902, quoted above, returns again and again to this idea: In studying the origin of new characters (1907*b*: 747), he arrives at the conclusions "that such origins [though arising independently] are predetermined by hereditary kinship" and that "this predetermination is due to a similarity of hereditary potential." In the next year (1908*a*: 150) he states that "heredity appears to dominate the origin of new cuspules in the teeth [of Titanotheres] because they arise in the form of rectigradation,[21] . . . controlled by ancestral affinity. That is, the *same* results appear independently in descendants of the *same* ancestors." In a somewhat later paper Osborn (1912*a*: 253) observes "both in respect to new cusps on the teeth and new horn rudiments on the skull [of Titanotheres] . . . what in our ignorance may be called an ancestral predisposition to the genesis of similar rectigradations. This predisposition betrays the existence of law in the origin of certain new characters. . . ." In his theoretical considerations concluding this paper Osborn (*ibid.*, 277) assumes "that certain germinal predispositions to the formation of new characters, connected, as Darwin conjectured, in some way with community of descent, are only evoked under certain somatic and environmental conditions, without which they appear to be in a latent, potential or unexpressed form."[22] In his paper on "Tetraplasy"[23] Osborn (1912*b*: 292) revives his 1902 concept of "potential homology," calling it "one of the most mysterious manifestations of the forces of heredity, which predisposes descendants of a similar stock, however remote, to give rise to similar new characters through heredity"; later (*ibid.*, 305) the principle of potential homology is said to be "based upon the observation that animals of similar kinship do not continuously evolve in certain directions but merely transmit a similar potentiality in the genesis of new characters."

Schindewolf (1936: 11), when attributing certain cases of parallelism to the "heritage ['Erbgut'] in common to the lineages concerned," adheres to the same idea; he explains (*ibid.*, 44) the "repeated and seemingly independent formation of triangular conchs" in three lines of Clymenids by the fact that all three lines "are closely related, derived from a common ancestral group, and inherited from it the potential for the assumption of triangular shape." (Translations from the German.) A similar way of thought seems to be alluded to in a more recent paper of the same author (1944: 279).

Finally, Hubbs (1944: 302), in discussing his "independent homologies," here believed to be a special case of homoplasy, after stating that "the same or a similar modification of homologous attributes may occur . . . in distantly as well as in closely related groups" adds: "Evidence keeps accumulating, however, to indicate that such independent homologies are particularly characteristic of closely related lineages.[24] In-

[20] Shown to be a synonym of homoplasy below.

[21] This term of Osborn's, created and first defined in 1905 (p. 961) to indicate "definite" or "orthogenetic variations," discussed anew in 1907 (1907*a*: 228–239), and redefined as "a qualitative change, the genesis of a new character" (in contradistinction to the allometron, which is "a quantitative change, the genesis of new proportions in an existing character") in 1912 (1912*a*: 250), does not fall within the scope of this paper, nor does "orthogenesis" with which it is closely linked. The latter term was proposed, according to Eimer (1898: 19, footnote 1), by Wilhelm Haacke in 1893 for the phenomenon first called "bestimmt gerichtete Entwicklung" (= definitely directed evolution) by Eimer and was accepted by the latter. (*Cf.* Fenton, 1931: 84, 85.)

[22] As Simpson has also pointed out, such cases may involve a different genetic process from the tendency for homologous genes to mutate in the same way. Some genes express their effects only under certain environmental conditions or in connection with other developmental factors (for instance, when a certain gross size is reached by the organism). In such cases, there may, indeed, be latent phenotypic characters that appear separated in different lines of descent but that are nevertheless due to the inheritance of the same genes which need not have mutated since the common ancestry (*cf.* p. 336).

[23] This term of Osborn's (1908*a*, 1912*b*), linked to homoplasy merely by the second half which both these compound words have in common, does not come within the scope of this study.

[24] Compare the above quotation from Fürbringer, 1888.

trinsic as well as extrinsic factors are probably responsible for this circumstance."

In our opinion, however, homology should be recognized only where there is clear observational evidence of a common origin of the similar characters; wherever new characters are independently acquired in different lineages, no assumption of some inherited latent or potential predisposition to similar changes should be deemed sufficient to consider those characters homologous instead of merely homoplastic.[25] In supporting this usage it is not meant to deny the possibility that somatic characters may arise independently because of the common inheritence of an underlying genetic basis. The intention is to reduce the subjective element in application of these phylogenetic terms by placing them as fully as possible on an observational plane. The relationship between the observed phenotypes and the genotypes, which cannot be directly observed and which are usually unknown in the present stage of research, is subject to separate consideration and need not be inherent in the usages of the terms here considered. The genetic processes here in question also have a bearing on the subject of parallelism and will be mentioned again in that connection (see below, p. 336).

SYNONYMS AND RELATED TERMS

(*a*) *Homology*

It has been pointed out above that, since homology in its modern meaning has come to indicate just what Lankester proposed to call homogeny, the latter term might well be dropped as a synonym of the former, notwithstanding Tait's (1928: 162) view that "homogeny . . . is not a thing of moonshine." Besides, the term homogeny is likely to be confused with homogeneity which has a much wider meaning; this applies in an even higher degree to the adjective homogenetic. Equally superfluous is its counterpart heterogenetic, as used, e. g. by Buckman (1895: 456, 457), whose meaning is rendered by "homoplastic" just as well. According to Fürbringer (1888: 1122, footnote 1), W. K. Parker used the term "symmorphy" instead of homology, but it seems hardly ever to have been used by other authors.

Synonymous with homogeny and, therefore, another synonym of homology is homophyly, which seems to have been used first by Palmén (1884: 17; *cf.* Fürbringer, 1888: 1122) in the adjectival form "homophyl." Both this adjective and "homophyletic"[26] are thus synonyms of "homologous."

(*b*) *Homoplasy*

The question whether or not analogy and homoplasy are synonyms has been examined and eventually answered in the negative above. Thus homoplasy is here not considered a synonym of analogy; nor is analogy a synonym of homoplasy, but there exist many others. Indeed, more synonyms of this term can be found in the literature than of any other here dealt with. This may be due, to a certain extent, to the fact that Lankester's original explanation of the term "homoplasy" was not readily understandable.

However, the first of the terms here to be discussed, Darwin's *Analogous Variations*, is not exactly a synonym of homoplasy. In the first edition of the *Origin of Species* (1860: 143–144) Darwin explained this term with the sentence quoted above (p. 326),[27] which says essentially the same as Lankester (1870*a*: 39) in his explanation of homoplasy as "the same forces [acting] on parts in two organisms, which parts are exactly or nearly alike and sometimes homogenetic" with "the resulting correspondences called forth in the several parts in the two organisms [being] nearly or exactly alike." Osborn (1902*a*: 261) listed Darwin's "Analogous Variation" among his various cases of "Analogy," though keeping it apart from Lankester's homoplasy, at that time not yet correctly understood by Osborn. In contradistinction to homoplasy, which is simply concerned with similarity that is *not* homologous (regardless of what it is), "Analogous Variation" is an attempt to *explain* homoplasy, coming fairly close to, though not exactly coextensive with parallelism (see below, p. 337, footnote 53), or may be considered a subdivision of homoplasy, adding a theory as to cause.[28] Al-

[25] Willey (1911: 89, 91) arrives at essentially the same result, but this phenomenon of "homoplastic modification of homogenetic structures" is to him "ordinal convergence" (*cf.* below, p. 333).

[26] For Moment's (1945) use of "homophyletic" see above, p. 324, footnote 11.

[27] Boyden's (1943: 232) interpretation that "in this application the term analogy refers to organs and parts which are not only specially homologous but almost identical" might be questioned inasmuch as it is the variations which were considered analogous by Darwin but not the organs or parts affected.

[28] Note by Simpson: It is thus a categorical alternative, within homoplasy, to analogy as I prefer to use this word.

though occasionally mentioned by later authors, Darwin's term has never become generally adopted; here, too, the younger, more neutral, and, at the same time, wider term homoplasy is given preference.

Another term which also antedates Lankester's paper of 1870 is ***heterology***, proposed by Cope (1868: 281) to designate "what Swainson and others called 'analogy' as distinguished from affinity." This very definition proves Cope's term to be synonymous with homoplasy, as here understood. It may be considered entirely obsolete.

Of later terms *homomorphy*[29] is considered—decidedly by Fürbringer (1888: 1122), doubtfully by Osborn (1902*a*: 261)—a synonym of homoplasy, which it seems indeed to be. This term was, however, not coined by Fürbringer, as Gegenbaur (1898: 25), Osborn (*loc. cit.*), Bourne (1910: 40), and Hubbs (1944: 301) believe, but is credited by Fürbringer (*loc. cit.*) to the Finnish naturalist J. A. Palmén who uses it in a paper of 1884 (p. 17), along with homophyly, in the following sentence: " . . . inwieweit Formen von Organen und Organe selbst, die wir jetzt homolog nennen, in der Tat *monophyletisch* entstanden, also *homophyl* sind, oder ob sie nur als *homomorphe* Endresultate *polyphyletisch* sich entwickelt haben."[30] To judge by this sentence, homomorphy may well be considered a synonym of Lankester's homoplasy.[31] Fürbringer (*loc. cit.*), however, rejects both terms for reasons of convenience and proposes to use W. K. Parker's "*isomorphy*" or "*isomorphism*," "as used in the morphological field," instead. Thus isomorphy (isomorphism) may here be disposed of an asother synonym of homoplasy; it is occasionally (e. g., Flower, 1941: 12, 49) used synonymously with homeomorphy also. In both meanings the use of this term should be discouraged for merely etymological reasons since it indicates full likeness of shape, hardly ever found in nature, not even between individuals of the same species.

[29] "Homomorphous," it is true, is listed already in Owen's (1843: 379) Glossary, but, as it would seem from his explanation "Of similar form," with no technical meaning.

[30] It could not be ascertained whether or not this sentence contains indeed the first (adjectival) use of both "homophyly" and "homomorphy" by Palmén.

[31] In the titles of Wilson, 1944 and 1945, "homomorphs" obviously means "homeomorphs," as understood in the present paper. However, we have been unable to find out what meaning is implied in homomorphy ("homomorphie") in Novikoff (1936) since this paper was not available.

Eimer (1898: 27) lists among his "eleven laws of evolution" "the law of independent similarity of development, or *homoögenesis*,[32] which states that the same directions of evolution may be operative in different and not immediately related forms and may lead to quite similar morphological results." From this definition it may readily be concluded that Eimer's term—used by Grabau (1913: 976 ff.) and, even more amply, by Dacqué (1921: 245–264; 1935: 131–140) in close connection with convergence, but otherwise not widely accepted—is just another synonym of homoplasy. Eimer (*loc. cit.*) adds that homeogenesis was "afterwards demonstrated by Hyatt in the *Arietidae* as morphological equivalents, and supported by examples from the shells of *Cephalopoda*."[33]

As a matter of fact, Hyatt formulated his concept of "*Morphological Equivalence*" first in 1884 (p. 361), deriving it from his "law of organic equivalence" as follows:

> The law of organic equivalence may be descriptively stated as follows, the action of physical changes takes effect upon an irritable organism, which necessarily responds to the external stimulants, by an internal reaction or effort. This action from within upon the parts of the organism modified their hereditary forms by the production of new growths or changes which are, therefore, adapted or suitable to the conditions of the habitat, or the physiological equivalents of the physical agents and forces from which they directly or indirectly originated. In so far then as causes and habits are similar they produce representation or morphological equivalence in different series and so far as they are different they produce the differentials which distinguish these series from each other.

Later (1889: VIII) Hyatt re-phrased this concept as follows: "*Morphological Equivalence.*—In the different genetic series of a type derived from one ancestral stock there is a perpetual recurrence of similar forms in similar succession, which are usually called representative and often falsely classified together, though they really belong to divergent, genetic series," adding (*ibid.*, IX): "These forms and their similar characteristics are not derived by direct inheritance from the common ancestor, in which all the forms are necessarily similar and primitive, but originate everywhere independently of hereditary

[32] Spelling of the English translation, quoted above. In his German papers Eimer spells the word "homoeogenesis."

[33] Since Hyatt's "Genesis of the Arietidae" appeared in 1889, this seems to imply that Eimer's term dates back at least to 1888.

influences in the different series, and also in all formations independently of chronological or chorological distribution." Thus Hyatt's earlier definition, although called descriptive by him, is seen to be explanatory in a Lamarckian sense, which is intentionally omitted from our concept of homoplasy. However, from his later definition it may, in our opinion, well be inferred that his morphological equivalents are nothing else than the result of homoplastic influences. This term, which has not become widely accepted either,[34] should, therefore, also be included, in a broad sense, in the synonymy of Lankester's older and shorter term homoplasy.

Finally, Hubbs' (1944: 300–302) "*Independent Homologies*" also turn out to be nothing else but special cases of homoplasy, as he himself indicates with the words: "They were apparently prominent in Lankester's mind when he first (1870) proposed the term homoplasy to designate the similar but independent modification of homologous structures." His statement that "the same or a similar modification of homologous attributes may occur on convergent or divergent as well as on parallel lines of evolution, and in distantly as well as in closely related groups" supports the above view; for all these modifications come under the wider concept of homoplasy. Hubbs is certainly right in emphasizing that the boundaries between analogy and homology are rather vague, but Osborn's (1902*a*—not 1907, as quoted by Hubbs—p. 270) sentence ". . . I think we have to deal with homology or, more strictly, with a principle intermediate between homology and analogy" does not seem well in point, dating, as it does, from the time when Osborn had not yet arrived at a clear understanding of Lankester's term homoplasy (see above, p. 322). The "examples of the identical but independent modification of homologous structures" taken by Hubbs (*ibid.*, 301) from the evolution of certain groups of fishes are to us cases of—heterochronous—parallelism or, in one case at least in which "the end results of such parallel evolution may be scarcely distinguishable on any morphological, physiological or developmental grounds," even convergence, if not homeomorphy. Hubbs' cases give us, on the other hand, good examples of morphological, if not homeomorphic recurrence (verb.: "repeatedly," "again and again") in the Clupeidae. Thus four or five preexistent terms may well be applied to the phenomena which Hubbs has in mind; there is really no need for a fifth or sixth, the less so since the phenomena named by him "independent homologies" are, in our opinion, independent, it is true, but not homologies.

[34] It is, e. g., repeatedly used by Buckman, in his paper on Brachiopod Homoeomorphy (1906), in the abbreviated version "morphic equivalent."

DIVERGENCE, PARALLELISM, CONVERGENCE

ORIGIN AND HISTORY

(*a*) *Divergence*

Although the realization of the phenomenon of divergent evolution is traced by Osborn (1902*b*: 353) as far back as to Lamarck, the creation of the phylogenetic term "divergence" apparently has to be credited to Darwin who masterly explained it in his *Origin of Species* under the heading "Divergence of Character" (1860: 103 ff.) and illustrated it by a classical diagram. Starting out, as usually, from experiences in breeding domestic animals, he writes: "Here, then, we see in man's production the action of what may be called the principle of divergence, causing differences, at first barely appreciable, steadily to increase, and the breeds to diverge in character both from each other and from their common parent."

It seems that the term has been used ever since, without any perceptible deviations, in the original meaning given it by Darwin.

(*b*) *Parallelism*

This term is younger than the precedent one, and may be said to have come into the world more or less incidentally. We are unable to clarify its origin fully. It seems to have been used first by Cope (1868, 1872: *passim*), but as Osborn (1902*a*: 260, footnote) observes, Cope gave it two different meanings: On one hand, as an equivalent of recapitulation (of the previous phylogeny in the ontogeny), as defined in 1872 (1887: 7) and, in an emended form, in 1896 (p. 20). The same meaning is implied in the heading for Chapter III of Part I of his *Primary Factors of Organic Evolution* (1896: 175–210; note, especially, on p. 176: "the parallelism between taxonomy, ontogeny, and phylogeny").[35] On the other hand, Cope used, though hesitantly as it were, this term in the modern meaning of parallelism of evolution also. Then, however, he spoke mostly of "the parallels," using the

[35] This use of "parallelism" is still found as late as in 1907 in Depéret (p. 83: "La loi d'Haeckel relative au parallélism du développement embryologique et du développement paléontologique des êtres").

noun "parallelism" only twice (1887: 98, 102). It thus seems that to Cope parallelism, as a technical term, meant recapitulation and that he used the word in its modern meaning only occasionally and incidentally.[36]

The first, at least in America, to use "parallelism" in its modern technical meaning and to define it precisely was W. B. Scott in his most important papers of 1891 (pp. 362 ff.) and 1896 (p. 56). For a critical analysis of his definitions reference is made to the next heading.

Some years later we encounter "parallelism" as a well established phylogenetic term, being used, for example by Buckman (1901: 231, 232, as "parallelism of development").

(*c*) *Convergence*

The place of origin of this term is found in the *Lectures on Man* of Carl Vogt, Professor of Geology and Zoology in Geneva, 1863 (p. 285). Discussing the family tree of the primates, he wrote:

> Der Typus Affe führt nach zahlreichen Richtungen auseinander; er teilt sich zuerst in zwei Hauptäste, Affen der alten, Affen der neuen Welt. Jeder dieser Hauptäste treibt weitere Äste und Zweige, die stets mehr auseinander zu fahren scheinen. Aber *die Vervollkommnung biegt die Zweige mit ihren Spitzen wieder gegeneinander.* Aus den so grundverschiedenen Familien der Gibbons, der Makaken und der Paviane entwickeln sich die drei menschenähnlichen Affen, die durch eine Menge gemeinsamer Charaktere einander bedeutend näher stehen, als die Gruppen, an deren Spitzen sie sich befinden (italics ours).

Hunt (1864: 468) translated the two last sentences, not quite literally, as follows:

> But *on arriving at perfection the twigs turn again towards each other*, so that from the fundamentally distinct families of the gibbons, Macaci, and baboons are developed the three anthropoid apes, which, by a number of common characters stand considerably nearer each other than the groups of which they are the heads (italics ours).

This very passage of Hunt's translation is quoted by Darwin in *The Descent of Man* (1871, I: 221–222), where he declares it to be

> possible, though far from probable, that the early progenitors of man might at first have diverged much in character, until they became more unlike each other than any existing races; but that *subsequently, as suggested by Vogt, they converged in character.* When man selects for the same object the offspring of two distinct species, he sometimes induces, as far as general appearance is concerned, a considerable amount of *convergence* (italics ours).

As seen from this quotation, Darwin here first refers to the phenomenon mentioned by Vogt, which *is* convergence in a technical sense, but—as if to create confusion from the very outset—immediately afterwards parallelizes it with the combination of the characters of two distinct species in their common offspring as a result of hybridization brought about by man, which *is not* convergence. The noun "convergence" is applied only to the latter phenomenon, but since Darwin applies the verb "to converge" to the former, justly crediting Vogt with its first description, he may well be considered the creator of "convergence" as a phylogenetic term (as distinct from the original geometric meaning of the word).[37]

Even though these facts clearly prove the Swiss-British origin of the term, it seems to have assumed a definitely German flavor afterwards, apparently because it was being used more generally by German students than by those of other nations. Thus Osborn (1902*a*: 260) speaks of "the 'convergenz' of German writers," even spelling the word the German way, and Traquair (1905: 882) attributes certain similarities as to position of eyes in eurypterids on the one hand and certain primitive fishes on the other to "what the Germans call a 'Convergenz-Erscheinung.'"

That the term was in the late nineties indeed quite familiar to German scholars, but much less so to English and American ones,[38] may be inferred from a comparison of the texts of Zittel's "Grundzüge" (1895: 14) and Eastman's first English edition (1896: 13): Whereas Zittel used the term (in the compound form "Konvergenzerscheinung," generally favored by German students, *cf.* below, p. 338), Eastman was reluctant to incorporate it in his text and paraphrased Zittel's expression instead—in the middle of an otherwise fairly faithful translation—by the rather cumbersome aggregate of words "phenomena of parallelism, or recurring 'common types of structure.'" Only in the second English edition (1913: 13) did Eastman adopt the term

[36] On the other hand, Cope was well aware of the evolutionary process covered by it, as seen from the above (p. 326) quotation, erroneously attributed to Scott by Osborn (1902*a*: 261, footnote), from his 1877 paper.

[37] The more so since in his index (1871, II: 399) p. 221 of vol. I is given for convergence, although the noun, in the above connection, occurs only on p. 222.

[38] In contradistinction to "parallelism," it cannot be found in any of Cope's papers referred to above.

"convergence," but still deemed it necessary to put it into quotes and to add the term "parallelism" which he obviously thought to be more familiar to his readers. Thus "Konvergenzerscheinungen" is now translated by "phenomena of parallelism or 'convergence.'"[39]

Strangely enough, a search of the German and Austrian literature of the last decades of the nineteenth and the first of this century did not yield any papers *explicitly* discussing or defining either parallelism or convergence. It seems that both were widely used on the European continent in teaching as well as in papers dealing with certain groups, but not made the subjects of any analytic studies. This impression is reinforced by Abel's (1909: (222)) complaint that "the term 'convergence' has recently been used very frequently and coined a catchword, as have so many terms in the field of evolution, but that the various students could not arrive at any uniform use of this designation." He adds that "in addition to the term 'convergence' the designations 'parallelism' and 'divergence' have come to be used more and more. . . ." The only author credited by Abel with "having, as the first, attempted a sharp analytical separation of the concepts: parallelism, convergence and divergence" is — H. F. Osborn (1905). (Translations from the German.)

In the meantime Scott had introduced "convergence" as well as "parallelism" in the American literature (1891, 1896), clearly defining them and emphasizing the importance of these phenomena for evolution in general. Under his influence Osborn also used and discussed them in some of his papers relating to general problems of phylogeny (1902*a*, 1905, 1097*a*; *cf.* Abel's reference quoted above).

Depéret (1907: 227 ff.), however, does not make any such clear distinctions as Scott and Osborn between parallelism and convergence. He attributes the "phenomènes de convergence" (obviously a translation of the German "Konvergenzerscheinungen") to "une sorte de marche parallèle" of the evolutionary modifications of certain groups, thus producing *appearances* of mutual approach even leading to confusion. Once more (*ibid.*, 234) he mentions "cas parallèles" of uncoiling in nautiloids on the one hand and ammonites on the other, but altogether he treats the phenomena here differentiated as parallelism, convergence, and homeomorphy under the heading convergence only.

In the course of the first decade of the twentieth century the term "convergence" seems to have become more familiar to English students as well as to American ones. In 1911 A. Willey published his book on *Convergence in Evolution*. Since both terms parallelism and convergence, though not their definitions, appear to be firmly established by then, their history as such need not be followed any further. However, the opinions of later authors as well as of those hitherto mentioned will have to be discussed under the following heading.

DEFINITIONS AND DISTINCTIONS

(*a*) *General Statement*

All three of the terms here discussed have their origin in geometry. It is believed that their usage in phylogeny will be clarified if their original geometric meaning is kept in mind.

If this general conception be adopted, it follows that each of these terms should be used to indicate only the mutual relation of two (or more) definite lineages during a certain stretch of time. Hence it follows further:

(1) That the same two lineages may be divergent, parallel, and convergent in consecutive time periods, even repeatedly so, as illustrated, though in a somewhat over-simplified way, by Willey's (1911: 70, 80, 112) figures 2, 5, and 11. This is obviously the meaning of that author's (*ibid.*, 69) "seeming paradox . . . that convergence depends firstly on divergence and secondly on parallelism."[40]

(2) That a certain stretch of the evolution of a given lineage may be divergent in relation to a second lineage, but at the same time parallel to a third, and even convergent with a fourth. To make this clear, let us imagine that of the four lineages ending up in the forms w^{14}, y^{14}, v^{14}, and z^{14}, in the upper right corner of Darwin's (1860, between pp. 108 and 109) diagram illustrating divergence the y- and v-lineages exhibit parallelism in one character, and the v- and z-lineages convergence in another character, between each other. Then the v-lineage would be convergent with the z-lineage, parallel to the y-line-

[39] In the first English edition the relative sentence "which are in no wise related to one another by inheritance," following the words "recurring 'common types of structure,' " made sense. However, this relative sentence was unfortunately left unaltered in the second edition, where it relates to "phenomena of parallelism or 'convergence.' "

[40] A similar conception may be found, as it seems, at the base of Schindewolf's (1944: 279–280) discussion of "Parallelreihen" (parallel series).

age, but still divergent in relation to the w-lineage. The z- and y-lineages would be, respectively, convergent with, and parallel to the v-lineage, but divergent in relation to the two others. The w-lineage, however, would still be diverging from all three of the others.

(*b*) *Divergence*

Of all the concepts under consideration this one seems to have been subject to the least amount of discussion and hardly to have needed any modernization. Schindewolf's (1944: 273, fig. 3) recent diagram conveys an excellent idea of the taxonomic implications of this concept, as conceived by modern phylogenetic standards, but it does not show any essential change, as compared to Darwin's.

Simpson's (1945: 12) sentence: "If the early members of two groups are more alike than the later, their later dissimilarities are divergent," may serve as an up-to-date definition of divergence.

Osborn, in proposing his "Law of Adaptive Radiation" (1902*b*: 354), calls it a "law of *local adaptive radiation* or incipient divergence on a smaller scale in a single locality" and explains it later (1910: 77) as "an application of paleontology of the idea of divergent evolution."

(*c*) *Parallelism and Convergence*

Notwithstanding Osborn's (1902*b*: 354) statement that homoplasy, parallelism, and convergence . . . are "by no means synonymous terms or identical processes" there has been, ever since these terms were born, plenty of divergence of opinion, not to say confusion, as to their definition and their delimitation from each other.

This confusion bears, to begin with, on the hierarchic order governing the relations between them: From Lankester's point of view, as conceived by Bourne (1910: 40) and, since 1905 (p. 228), by Osborn (see above, p. 322), homoplasy is the higher category, including both parallelism and convergence. This is the opinion adhered to in this study. Bourne (*loc. cit.*), however, considers parallelism a mere synonym of homoplasy, and, speaking of "a contrast between homoplasy and convergence," leaves us in doubt whether these two concepts are coordinated or if the second is subordinated to the first. Willey (1911), in turn, considers, rather surprisingly, convergence the higher category, including homoplasy,[41] mimicry, and parallelism,[42] thus even arriving at a term "parallel convergence" (*ibid.*, 78) which, by the way, is one of the finest examples of a *contradictio in adjecto* to be encountered in scientific literature.[43]

Even worse appears to be the confusion as to definitions of the various concepts themselves. With very few exceptions the definitions given for the one are applicable to the other equally well or even better, or they may even cover the other but not the one they are intended to define.[44]

Thus Zittel's explanation of "Konvergenzerscheinungen," quoted above (p. 326, footnote 18), defines homoplasy rather than convergence. Eastman's sentence in the second English edition of Zittel's textbook (1913: 13), as quoted on page 332, lumps two processes (parallelism and convergence) which are distinguishable after all. The words used in the first English edition (1896: 13, see above, p. 331) are certainly even less satisfactory as a definition of the phenomena of convergence which they were intended to be.

Even those students who make a clear theoretical distinction between parallelism and convergence emphasize the difficulty of its practical application. Scott (1891: 363) points out: "The distinction between the two classes of phenomena is obviously one of degree rather than kind." Simpson (1945: 9) also calls "the distinction . . . far from absolute," adding: "The two phenomena intergrade continuously and are often indistinguishable in practice."[45] Scott's (*loc. cit.*) conclusion that "it will therefore be convenient to consider them together" is valid for the present study also, not only for the reason pointed out by him, but also for those discussed in the preceding paragraphs.

[41] "All homoplasy is convergence, but all convergence is not homoplasy" (*ibid.*, 12).

[42] " . . . a third way of convergence known as parallel evolution" (*ibid.*, 57).

[43] As mentioned above (p. 332), convergence is the dominant concept to Depéret also, but he does not include homoplasy, this term being apparently unknown to him.

[44] Good evidence of this confusion may be found in Henderson and Henderson's (1929) definitions of convergence (p. 60) and homoplasy (under "homoplasty," p. 137).

[45] Darwin's (1860: 143–146) pigeon example, quoted above (p. 326), may well serve to illustrate these difficulties of distinguishing the two phenomena in practice. At first sight, it might appear as a typical case of parallelism (between man bred races), but features of convergence are also recognizable in the following words taken from Darwin's description of the phenomenon:" . . . a variety of one species often assumes some of the characters of an allied species" (p. 143), "so that a variety of one species would resemble in some characters another species" (p. 145), "mocking, as it were, some of the other species of the same genus" (p. 146).

Here, as in similar cases, a clear differentiation between the two neighboring concepts is the best way to arrive at suitable definitions.

Apparently the first to attempt such a differentiation was Scott (1891: 362): "If the various species of the ancestral genus acquire the new character independently of each other," there is parallelism; "if the species of widely different genera . . . gradually assume a common likeness," there is convergence. In his Wood's Hole Lecture of 1895 Scott (1896: 56) gave the following definitions:

> By parallelism is meant the independent acquisition of similar structure in forms which are themselves nearly related, and by convergence such acquisition in forms which are not closely related, and thus in one or more respects come to be more nearly alike than were their ancestors.

It will be noted that the last part of the latter definition indicates the geometrical meaning of the word as an essential characteristic of convergence, but the *differentia specifica* between the two processes is still the degree of relationship between the lineages involved.

In his earlier paper (1891: 362) Scott emphasized "the deceptive character" of these processes, meaning that they simulate a relationship which is not really present (as all phenomena of homoplasy necessarily do), and pointed out that their deceptiveness "may generally be unmasked upon careful examination, though even here the cases of the Ammonites . . . show the need of extreme caution."[46] In his second paper (1896: 54) he adds that "Paleontology enables us accurately to discriminate between resemblances which are due to genetic affinity and those which result from parallelism or convergence"—or, in the terminology here proposed, between homologous and homoplastic similarities.[47]

Osborn (1902*a*: 261) adopted Scott's differentiation, basing it merely on the antithesis: related—unrelated, thus provoking the following criticism by Willey (1911: XI): "These definitions leave us in the dark as to what degrees of relationship would entitle a given case to be classed as one of parallelism or of convergence." In his chart of 1905 (p. 960), reproduced by Abel (1909: (223)), Osborn distinguished "analogous adaptations, i. e. similar characters arising independently in *similar or related animals or organs*, causing a similar evolution, and resulting in *parallelisms*" and "similar adaptations arising independently in *dissimilar or unrelated animals or organs*, causing a secondary similarity or approximation of type, resulting in convergence." Adding similarity and dissimilarity as a second pair of characters to relationship and non-relationship was apparently intended to give a broader base to the distinction, but it may be doubted if it made it any clearer.

Abel (1909) attempted to improve these definitions; to him the essential difference between parallelism and convergence is given by the fact that the former brings about the same result of transformation in both forms concerned, the latter a more or less similar one. For parallelism the "homodynamic function of homologous organs" is considered essential, for convergence that of heterogenetic ones. Thus, Osborn's requirement of non-relationship is maintained for convergence, but parallelism is said to occur between "verschiedenen, nicht näher verwandten Arten (different species, not related to any considerable extent)."

Dacqué (1921: 253) essentially repeats Abel's conception, slightly modifying the above requirement of parallelism to "verschiedenen, nicht immer verwandten Arten (various, not always related species)"; on the other hand, he not only admits convergences in closely related species and genera, but even finds them to be the most comprehensible ones (*ibid.*, 251). In addition to Abel's concept of convergence, he lists two more which might be called constitutional convergence and accidental convergence, respectively (*ibid.*, 257, 261–262). All of them

[46] As a case of "mental parallelism" it may be worth mentioning that Depéret—who does not seem to have known Scott's writings—expressed the same thoughts with almost the same words: "Certains organes conservés à l'état fossile . . . puissent arriver, dans des groupes distincts, à converger d'une manière assez complète pour tromper l'observateur" (1907: 228). "Presque toujours il est facile au naturaliste de démasquer ces analogies trompeuses en faisant appel à l'ensemble de l'organisation" (*ibid.*, 236).

[47] *Cf.* Buckman, 1925: 9: "It is by analyses of characters . . . that the descent and the biological position of families and genera are to be worked out—not by rash assumptions of affinity from general similarity, which too often may be merely homoeomorphic deceptions"; Simpson, 1945: 10: "Homology is always valid evidence of affinity. Parallelism is less direct and reliable, but it is also valid evidence within somewhat broader limits. It may lead to overestimates of degree of affinity, but it is not likely to induce belief in wholly false affinity. Convergence, however, may be wholly misleading, and a principal problem of morphological classification on a phylogenetic basis is the selection of characters that are homologous or parallel and not convergent."

come anyway within homoplasy, as here understood. In his later book (1935: 124, 131–140) Dacqué seems to return to the earlier distinction, as made by Scott; if the initial species or genera are related, there is "more or less parallel, though slowly converging transformation (homeogenesis)"; if they are not, there is "genuine convergence," or "heterogenetic repetition (heterogenesis)."[48] (Translations from the German.) Even though, in this passage as in many others, Dacqué does his best to confuse the terminology, parallelism and convergence may still be recognized as the two limbs of this antithesis. A few pages later (*ibid.*, 135), he equals "Parallelformenbildung" (parallelism) to Eimer's orthogenetic homeogenesis and distinguishes it from convergence by the following internal criterion: The former is said to be based on "primarily the same basic organization, producing necessarily the same formation of organs, e. g. for the fulfillment of the same requirements of life, whereas convergence does not arise from a 'innere typenhafte Bindung' (= internal type-bound organization), but occurs when like conditions transform beings of entirely different basic organization." Analogous transformations of heterogenetic forms, which may be isochronous or heterochronous, are claimed to be always convergence. (Translations from the German.) Obscure as these comments are, they seem still to reinforce the assumption that Dacqué in 1935 based the distinction primarily on relationship. However, he still admits, as he did in 1921, convergence between related forms (*ibid.*, 132, 135); on the other hand, he leaves the question undecided whether to explain the stunted development of the eyes of cave dwelling animals, be they amphibians or mammals, by convergence or by parallelism (*ibid.*, 135).

As indicated above, Willey (1911), probably the first author to write an entire book on convergence, gives this concept a far broader scope than usual. His definition is as follows (*ibid.*, 52):

> The term convergence is applied to resemblances amongst animals which are not due to direct relationship or genetic affinity; in other words, which are not derived by inheritance from common ancestors, but which result from independent functional adaptation to similar ends.

This definition, as it stands, is of no assistance for the distinction under consideration. The same applies to Dendy's definition (1923: XXII):

> The acquisition, by different organisms, of similar form or structure as the result of a similar mode of life, and not as the result of inheritance from common ancestors.[49]

Annandale's (1924: 2) definition of convergent evolution,[50] although rather wordy and altogether unsatisfactory for our purpose, is of interest to us because it admits the possibility of convergence between related organisms.

Even such a standard work as Diener's *Grundzüge der Biostratigraphie* (1925: 8–9) deals with convergence only (under the name "Konvergente Anpassung," convergent adaptation), without even mentioning parallelism; thus it cannot give us any clue to the solution of the present problem.

Schindewolf, in an interesting paper of 1940, starts out (p. 228) to give a preliminary, "uncritical" definition of convergence as "similarities in shape which have arisen on different organizational bases and, therefore, are not based on immediate relationship." It will be clearly seen that this definition covers the whole scope of homoplasy, as defined above (p. 325). In distinguishing convergence from parallelism on the one hand and from "iterative repetition of always the same evolutionary courses" (= iteration Beurlen) on the other, he proceeds to declare: "A true convergent evolution cannot occur within one and the same phylum [Stamm], within the same fundamental organization" and

[48] As a technical term, heterogenesis was proposed by Korschinsky (1899: 273) to designate "the unexpected appearance, amidst a homogeneous offspring of normal parents, of single individuals sharply distinct from the others. The adult individuals preserve all their peculiarities and transmit them to their offspring, thus giving rise to a new race." (Translation from the German.) Korschinsky intended his term to replace the older expressions "Spontaneous Variation," "Heterogeneous Generation" (Kölliker), "Heterogenism" (Hartmann), but, as a matter of fact, it was in turn replaced by the genetical term mutation. "Heterogeny" conveys a meaning different from "Heterogenesis" (see Dendy's, 1923, Glossary, XXVII). As used by Dacqué, the latter term seems to indicate the opposite of Lankester's homogeny. As to Cope's "Heterology" see above, p. 329.

[49] Even less satisfactory is Dendy's definition in the text of his book (p. 258): "The evolutionary process by which analogous but not homologous structures have come to resemble one another is sometimes spoken of as convergence."

[50] ". . . when living organisms not related in general structure (or, if related, not of precisely the same origin) manifest similarities either in particular organs, in general facies or in instinct, provided that these similarities are directly correlated with special functions or with a similarity of environment."

to suggest that the term convergence be reserved "to the cases of mutual approach in shape between members of different phyla [Stämme] in which the similarities affect merely analogous organs of very different origin and structure." (Translations from the German.) Here, then, Scott's differentiation: parallelism between related forms, convergence between unrelated ones, is seen at its peak.

Simpson (1945: 9) also adheres, though much less decidedly, to that differentiation. After distinguishing homology from convergence by attributing the resemblances to inherited like characters in the former phenomenon, but to independently acquired like characters in the latter, he continues stating that

> a third sort of process also produces similarities: parallelism. The term is descriptive rather than explanatory and refers to the fact that distinct groups of common origin frequently evolve in much the same direction after the discontinuity between them has arisen, so that at a later stage the phyla may have characters in common that were not visible in the common ancestry but that tend, nevertheless, to be more or less in proportion to the nearness of that ancestry. This proportional tendency distinguishes parallelism from convergence.

On the other hand, Simpson admits that "the maximum possible effects of convergence tend to be in proportion to nearness of affinity" and also does justice to the "geometric" concept of parallelism and convergence, as here advocated, with the following distinction:

> If the early members of two troups are more alike than the later, their later dissimilarities are divergent If the early members are less alike, their later similarities are convergent. If the early members are much alike and the later members have further likenesses, these are parallel.

Moret, in his textbook of paleontology (1940: 27) explicitly admits convergence within the same group.[51]

Finally, an indication of what has been called above the "geometric" concept of convergence is found in Kroeber (1943: 108):

> In short, it is because the basic patterns differ that the similarity is convergent. The histories are unlike, the secondary results are like . . . though the like results need not be superficial or trivial—in fact may be accompanied by pervasive modifications of the organism.[52]

From the preceding survey of opinions it would appear that Scott's original distinction between parallelism and convergence, based on the degree of relationship between the lineages involved, is still the dominant one. The following considerations make this fact well understandable:

On the one hand, parallelism occurs, it is true, between more or less related groups. The concept that clearly underlies the use of parallelism in the sense of Scott and of most, but not all, later authors is that this process or phenomenon involves characters that arise after separation from a common ancestry but that nevertheless are in some way due to the existence of that community of inheritance. The widespread belief in such a connection has been exemplified on previous pages (pp. 326–327) and one of us (Simpson, 1945: 9–10) has emphasized that there are at least two known genetic processes that would lead to these results without recourse to such vague or metaphysical ideas as phylogenetic "predetermination" or "latent" characters. There is little doubt of the reality of these phenomena and these real phenomena correspond with the conception of parallelism as a sort of homology, but a sort that does not reach phenotypic expression until after the separation of the two or more lines concerned. Thus there is a real validity in the idea of parallelism in the sense of Scott and of those who have followed his definition, although the basis for this validity has usually been obscured. A restatement in acceptable modern terms has not been made although that of Simpson (1945) may perhaps be considered as an approach toward this. The main difficulty has been retention of the rather crude and historically out-dated criterion of nearness or distance of affinity as the distinction between parallelism and convergence. The intended distinction would have been validated if it had earlier been expressed in genetic terms.

Redefined in such terms, parallelism would be similarity in structure due to a common genetic basis (and so far resembling homology) but not reaching morphological expression until after the separation of the two or more lines involved (and in this differing from homology). This seems really to be the concept toward which earlier students were progressing, gropingly in the absence of clearer genetic knowledge, from two different directions: when they spoke of parallelism in the sense of Scott as similarity arising in nearly related lines (i. e., with a considerable common genetic basis), and when they spoke of latent or potential homology and the

[51] "Les phénomènes [de convergence] se produisent souvent à l'intérieur du même groupe."

[52] In a preceding sentence of Kroeber's (*ibid.*), however, analogous and homoplastic features, in the usage of this paper, seem to be slightly confused.

like (i. e., of a common genetic basis for characters not morphologically evident until a later stage in phylogeny).[53]

This phenomenon is a special case of homoplasy and is logically on a level with homology because it offers an alternative explanation of similarities, which homoplasy does not do. It is, clearly, not the only alternative to homology. (Analogy in the sense of Simpson, but not of Haas, is another and there are still other possibilities.) This restatement makes it clear that the phenomenon is not to be defined entirely in terms of nearness or distance of the common ancestry, although this factor is important in it. Even very distantly related animals have some genetic factors in common, but these are more numerous the nearer the phylogenetic positions of the animals concerned. Therefore the intensity and frequency of this phenomenon will tend to vary with nearness of relationship.

So far, the position seems clear. It is possible to gather together broadly diverse expressions and ideas of the past and to relate them to a definite and modern restatement of a phylogenetic principle. It remains, however, to decide whether to define or redefine parallelism as the term applicable to this principle. On historical grounds this would be justified and perhaps preferable because this genetic definition is closer to the usage of Scott and of most later authors than is the strictly geometric definition. Nevertheless, we have decided against such a proposal (very reluctantly, as concerns one of us) because of the inappropriateness of the term. Parallelism does have a vernacular, or at least a non-phylogenetic sense, which is applicable to the phenomenon in question only in a descriptive way, whereas the essence of genetic definition would be to supply a theory or opinion as to the cause underlying the descriptive situation. This genetic principle is not the only one that can produce a sequence descriptively parallel. Moreover, the result of this genetic factor is not necessarily parallelism in a descriptive sense.

It can, indeed, be convergence in this sense although convergence has almost always been considered as essentially distinct from parallelism. One of the reasons for this view, and probably the decisive one, has been that convergence may be found between groups far distant from each other in the zoological system, as in the classical example of the Devonian coral *Calceola*, the Permian brachiopod *Richthofenia* and the Cretaceous pelecypod *Hippurites*,[54] all of which assume, under similar conditions of environment, the same horn-like shape and closely approximate each other even in some details of internal structure; such cases are so conspicuous and striking as to focus on themselves the attention of naturalists studying convergence.

It cannot be doubted, however, that it may also occur between related groups, even between species of closely related genera or even of the same genus. Among the best known examples are the various lineages of the Upper Jurassic group of *Ammonites mutabilis* Sow. (nowadays referred to the genus *Proplanulites* Teisseyre by Roman (1938: 266), but to the genus *Rasenia* Salfeld by Arkell (1946: 12, 15)) which converge to such a degree as to become homeomorphs, as described by Würtenberger (1880: 85–86, 106–107). Here it is only the ontogeny of the forms compared by that author which, thanks to the law of recapitulation, betrays their different origin.[55] A similar case of different ammonite species assuming in maturity the same characters so as to converge into one polyphyletic species is that of the Lower Cretaceous *Crioceras duvali* Léveillé, as described by Nolan (1894). Brinkmann (1929) also reports cases of smallest convergences among his cosmoceratids (*cf.* Dacqué, 1935: 118). Another case of intrageneric convergence is reported, under the designation homeomorphy, by Buckman (1901: 238–239) to occur between "two nearly related fossils [of the Inferior Oolite], namely: *Terebratula plicata* and *T. fimbria*" both of which develop similar multiplication of ribs. On a somewhat higher taxonomic level convergence "of several different genetic series" into the genus *Baculites* was assumed by Hyatt (1894: 579), just as W. D. Smith (1905: 653) found "that a number of 'morphological equivalents,' to use Hyatt's

[53] Darwin's "analogous variations" falls exactly under this concept, although it is not coextensive with the concept as a whole and of course did not involve knowledge of the mechanism of heredity (*cf.* above, p. 328).

[54] To the three forms named above Dacqué (1921: 252, fig. 91) added a balanid exhibiting a very similar shape of its shell.

[55] "Here these end members became so similar to each other that several of them were even united into a single species, and we might even speak of a polyphyletic origin of the species. Similar as the outer whorls of such *mutabilis* forms may become to each other, the inner volutions are the more different and disclose but too clearly the diversity of origin of individuals which have even been lumped into one species; thus such a polyphyletic species turns out to be merely an unnatural compound of different things to be dissolved automatically by a system based on the genetic relations of the forms." (Translation from the German; Würtenberger, 1880: 106–107.)

expression, have been grouped together as species of one genus; that this genus [*Scaphites*] is polyphyletic, and not monophyletic, as it has been treated heretofore. . . ." His opinion was shared by Pervinquière (1907: 117) and Nowak (1912); the latter split the old genus *Scaphites* up into three genera: *Holcoscaphites*, *Acanthoscaphites*, and *Hoploscaphites*, deriving each of these converging series from another ancestral genus, viz. *Holcostephanus*, *Acanthoceras*, and *Hoplites*.[56]

That all the above examples are taken from the Ammonoidea may not be purely incidental but owing to the fact that hardly any other group of invertebrates lends itself so well to studies of evolution in general.[57] Scott (1896: 57) missed among the vertebrates cases "where all these structures [i. e. teeth, skulls, or feet] have become alike through the operation of either parallel or convergent development," though adding: "Among the invertebrates the case is different." However, although he knew well, and referred to the cases of convergence studied by Würtenberger and Hyatt, Scott (1891: 366–367; 1896: 57–58) failed to draw the obvious conclusions that also closely related lineages may converge, as admitted by Dacqué and Moret (see above quotations).

Since, therefore, a high degree of taxonomic distance between the initial members of the converging lineages is, in our opinion, not essential for convergence, we have decided to support strictly geometric definitions, viz. of *parallelism* as homoplastic modifications in two or more lines producing similarities which do not increase with evolution, and of *convergence* as such modifications producing similarities which do increase with evolution.

As in the case of homoplasy, common usage applies these terms to the results of these evolutionary processes as well as to the processes themselves. However, the former[58] German term "Konvergenzerscheinungen" (= phenomena of convergence or, more precisely, phenomena due to convergence) took that distinction fully into account.

It must be admitted that the solution chosen above leaves unsettled the problem of terminology for the more theoretical and genetical principle to which we propose denying the appellation of parallelism. In spite of its somewhat metaphysical undertone, the expression "latent homology" might not be inappropriate, but this is outside the more strictly morphological-phylogenetic scope of our discussions and we are not prepared to make a definite proposal at this time.

From the above "geometric" conception of parallelism and convergence it follows that only the latter but not the former may lead to homeomorphy, to be discussed under the next heading.

SOME EXAMPLES OF PARALLELISM AND CONVERGENCE

So far only examples of convergence have been given, in most of which (*Calceola-Richthofenia-Hippurites;* group of *Ammonites mutabilis; Crioceras duvali; Baculites*) such a high degree of convergence is reached that they might serve as examples of homeomorphy as well.

An excellent illustration of parallelism—between a horse and a titanothere, both of the Middle Eocene—is given in Osborn's (1908*b*) figure 3, showing how new cuspules rise independently in both. This is, in our opinion, an example of parallelism but not of convergence, because the appearance of these new cuspules in both lines does not bring them morphologically closer together than they were before.

Another good example of parallellism, also taken from the evolution of the mammals, is given by Scott (1891: 364). He cites the independent acquisition of "the prismatic cement-covered molar in many forms; e. g. several of the ruminants, certain pigs, the horses, one of the rhinoceroses (*Elasmotherium*), the elephants, many rodents etc." Scott adds: "The resemblance of the molar of *Elasmotherium* to that of the horse is very striking, but its fundamental plan is rhinocerotic and not equine." This sentence indicates that, despite the appearance of the same modification in both, the one is still a horse tooth, and the other still a rhinoceros tooth. Their fundamental plans have not approached each other, which is a clear criterion for this modification being parallelism but not convergence.

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[56] The bearing of (isochronous) convergence on polyphyletic origin of genera etc. will explicitly be dealt with under a following heading (pp. 341–342).

[57] See, e. g., Waagen 1869; Würtenberger, 1880; Hyatt, 1884, 1889, 1894; Salfeld 1924; Brinkmann, 1929; Schindewolf, 1936, 1940. Next to ammonites, trilobites, gastropods, and brachiopods seem most to have favored such studies; see, e. g. Beecher, 1921, for trilobites and brachiopods; Grabau, 1902–1912, 1904, 1910, 1913, for gastropods; Buckman, 1895, 1901, 1906, Grabau and Reed, 1912, and Fenton, 1931, for brachiopds.

[58] In more recent works of German students, e. g. Dacqué, 1921, 1935, Schindewolf, 1940, "Konvergenz" indicates both the process and its results.

Among invertebrates, Buckman's (1906), plate XLI, although meant to illustrate "Brachiopod Homoeomorphy," shows a beautiful case of parallelism in diphyoid terebratulids, both isochronous (as far as the three Portlandian—Neocomian series in relation to each other are concerned) and heterochronous (there being, in addition, a Liassic series). The parallel lineages undergo the same changes, but their respective members do not thereby become more similar then their predecessors, although it has to be admitted that even at the earliest stages there prevails already a very high degree of similarity. On the whole this chart of Buckman's illustrates, in our opinion, parallelism, not convergence or homeomorphy.

A somewhat different picture is found in Schindewolf's (1936: 42) figure 25, illustrating the independent evolution of triangular shell shape in three lineages of Upper Devonian *Clymeniae*. Schindewolf calls these three series parallel, which they are indeed in the lower half of the diagram, after having diverged at its base. In its upper half, however, the lines II and III (line I does not reach up that high) become convergent, this convergence leading even to homeomorphy in the end members which can, according to the author (*ibid.*, 43) be distinguished merely by their suture lines. Thus this case yields a good illustration for the statement made at the very beginning of the preceding section (p. 332) that the same two lineages may be divergent, parallel, and convergent in consecutive time periods.

HOMEOMORPHY[59]

ORIGIN, PREVIOUS DEFINITIONS

Buckman, after having used the adjectival form "homoeomorphous" in an earlier paper (1895: 456), defined in 1901 (pp. 231–232) his term "homoeomorphy" as "the phenomenon of species nearly alike so far as superficial appearance is concerned, but unlike when particular structural details are closely examined," and derived it from "the phenomenon known as parallelism of development."

In the decades to follow, the term was used in this meaning by Buckman himself as well as by other paleontologists (see Cloud, 1941: 900).[60] Cloud, in a paper on "Homeomorphy and a remarkable illustration" (1941: 899), redefines homeomorphy "as the phenomenon of general superficial resemblance but dissimilarity in particular structure," thus making Buckman's original definition, without any essential change, more concise.

Schindewolf (1940: 230) advocates a "neutral" use of the term homeomorphy to designate "similarities in shape, resulting from parallel or divergent courses of evolution." (Translation from the German.) In the same year Moret (1940: 27), after mentioning the possibility of convergence within one and the same group, gives the following examples: ". . . ainsi deux Ammonites, d'origine nettement differente, peuvent avoir une coquille tout à fait semblable" and concludes: "on dit alors que ce sont des espèces homéomorphes."

REDEFINITION

Of the various opinions just surveyed, Cloud's and Moret's come closest to our own. To us homeomorphy is the result of a convergence which has gone so far as to produce a similarity affecting the whole outer appearance of the homeomorphs to such a degree that the one may be mistaken for the other unless certain internal or other characters requiring close examination are studied. Thus conceived, homeomorphy represents the deceptive character of all homoplastic modifications, as discussed above (p. 43), at its peak, permitting Buckman (1925: 9) to speak of "homoeomorphic deceptions" and Cloud (1941: 901) of "the pitfalls of homeomorphy." Characters whose examination makes the distinction of homeomorphs possible after all may be found, e. g., in the earliest (innermost) volutions (Würtenberger, 1880: 106–107) or in the suture lines of otherwise deceptively similar ammonites (Dacqué, 1921: 250; Haas, 1942*a*: 645).

The conception of homeomorphy here proposed causes the boundary between it and convergence to be vague, since the former phenomenon is considered merely a special case of the latter. Moreover, the above criterion of "interchangeability" requires elastic interpretation,

[59] In accordance with modern American usage, the Greek diphthong "οι" is rendered in our spelling of this term, as of others including the Greek "ὅμοιος," by a plain "e." We are, however, well aware of the disadvantage of this usage which makes it impossible to recognize whether an "e" found in a term derived from the Greek stands for "οι" or for "αι," both "καινὸς" (= new) and "κοινὸς" (= common) being rendered by the same plain "e" (*cf.* Schenck, 1943: 636, ref. 7).

[60] Seitz (1929) distinguishes, within the paleontological terms relating to parts of organisms only, homologous and "homoömorph" terms, the latter being the purely morphologic ones.

according to the taxonomic distance of the converging groups; thus, in the famous example *Calceola-Richthofenia-Hippurites* it might be deemed sufficient that a pelecypod or a brachiopod may be mistaken for a coral, whereas in the case of intrageneric convergence, as in Würtenberger's *Proplanulites* or in Nolan's *Crioceras* quoted above (pp. 337, 338), only such forms as are practically indistinguishable except for certain internal, not readily accessible characters may justly be called homeomorphs. Thus the three examples of convergence cited above may serve just as well as examples for homeomorphy, but of course, this does not apply to all cases of convergence. For excellent illustrations of homeomorphy reference is especially made to Dacqué's book of 1921.

The redefinition here attempted is bound to remain incomplete as long as the subjective element is not taken into account, i.e., the question who may be expected to mistake or not to mistake the one thing for the other. It seems that in this respect the inexperienced layman, who can rarely, if ever, distinguish a brachiopod from a pelecypod, should be excluded as well as the specialist, since, e. g., a paleontologist who has done specialized work on rudistids will hardly be unable to recognize, even at first sight, a homeomorphous coral or brachiopod as something different. Rather should the impression and judgment of the trained naturalist be considered decisive.

From this angle certain cases in which the expression "homeomorphy" comes too readily to mind ought to be excluded, at least from the technical meaning of this term. If, e. g., an uncoiled, though curved Cretaceous ammonite from Angola (*Anisoceras saussureanum* [Pictet], var. *spinosa* Haas, 1942*b*: pl. XLVI, fig. 2*a*) strikingly resembles some caterpillars, this resemblance will not fool any trained naturalist who knows well that it is the shell of the ammonite which becomes petrified and that caterpillars lack an outer integument capable of being fossilized in the same way. As another case in point, though perhaps a border line case, might be cited the similarity of a colony of *Favosites*, a Paleozoic tabulate coral, and a honey-comb which not only again and again misleads the layman but even accounts for the generic name (*favus* = honeycomb). Here both structures are built by invertebrates belonging to groups far distant from each other to house the individuals of the colony in one case and its offspring in the other. Were it not for the fact that the structure is subject to fossilization in the former case but not in the latter, the term homeomorphy might be applicable to this example even under our preceding restrictions.

Thus, we arrive at the definition of homeomorphy as a similarity of two or more organisms or structures[61] affecting their whole outer appearance and reaching such a degree that, unless certain internal or obscure characters are examined, the one may be mistaken for the other even by a trained naturalist. The similar organisms or structures are called homeomorphs in relation to each other.

HOMEOMORPHY VS. MIMICRY

Both Buckman (1901: 232) and Cloud (1941: 899) emphasize the connection between these two phenomena. The former considers mimicry as "one phase of homoeomorphy"; the latter urges "the wider usage of the second term in preference to the commonly misused word 'mimicry.'"[62]

It is true that certain cases of mimicry involve homeomorphy, for example the (predominantly female) butterflies, quite recently discussed by Goldschmidt (1945), which copy other species, distasteful or otherwise repulsive to predators, or harmless insects which imitate in their appearance dangerous ones belonging sometimes to taxonomically far distant groups (see Dendy, 1923: 254, fig. 177). However, mimicry includes many other cases which can by no means be considered homeomorphic as the term is here understood. The grasshopper or butterfly copying a leaf, the "walking sticks" imitating dry sticks, or, least of all, the fish mimicking dead leaves, as vividly described by Willey (1911: 64–65), certainly do not come under our above definition of homeomorphy. Once separated from its environment, the mimic could hardly ever be mistaken for its model, nor the latter for the former. Furthermore, mimicry, as defined in modern biology, requires that the resemblance be advantageous to the mimic, whereas home-

[61] The "convergence presque complête" between dermal plates of armadillos on the one hand and the reptile *Placosaurus* on the other, reported by Depéret (1907: 231), might serve as a good example of homeomorphy between single structures.

[62] Since Willey's convergence includes, among other things, the phenomenon here called homeomorphy, his statement (1911: 56) that "in less obvious cases it is often as difficult to separate pure convergence from . . . mimicry as it is to distinguish it from homology" should also be quoted here; his book includes a full chapter (V, pp. 52–68) on "Mimicry and Homoplasy."

omorphy, as a purely morphologic concept, does not imply any such element, nor any distinction between mimic and model, putting, as it does, both (or all) homeomorphs on an equal level.

Thus mimicry is not, as has sometimes been assumed (Buckman, 1901: 232), a "phase" or a special case of homeomorphy. Can, on the other hand, the latter perhaps be included in mimicry? Certainly not, since mimic and model cannot but live together in time, area, and environment, a requirement which will come true for only a very small proportion of all cases of homeomorphy recorded and observable in the field of paleontology. We thus arrive at the conclusion that the two concepts overlap.

Buckman (*loc. cit.*) utters the opinion that "Mimicry may be suggested in regard to homoeomorphous species," giving ammonites of the genera *Dumortieria* and *Grammoceras* as an example, but he adds immediately: "It would be, perhaps, impossible to prove mimicry in regard to fossils." Even where in the extremely restricted field of extinct homeomorphs, which lived not only contemporaneously but also in the same area and environment, there should be some reason for assuming mimicry, there will indeed be no way of proving it and, even less so, of correctly distributing the roles of mimic and model between the homeomorphs. Therefore, paleontology will hardly ever be able successfully to use the term mimicry.

SYNONYM; PHONETICALLY SIMILAR TERMS

As mentioned above (p. 329), some authors (e. g., Flower, 1941: 12, 49) use the term "isomorphy" instead of homeomorphy; however, for the reasons previously stated, it should be rejected as a synonym of homeomorphy as well as of homoplasy.

The phonetically similar terms "homomorphy (homomorphie)," "homomorph, homomorphs," and "homomorphous" have been discussed above (p. 329).

By way of appendix to this heading we may briefly discuss two terms that have not yet been dealt with in the present study: *Homeosis*[63] was originally proposed by Bateson (1894: 85) as a substitute for the earlier term "metamorphy," to indicate "that something has been changed in the likeness of something else." Bridges and Dobzhansky (1933: 575) defined "hereditary homoösis" as the "radical alteration of the morphology of an organ [owing to a mutation, or] . . . disappearance of the organ and the development of another organ in its place." *Heteromorphosis* is considered a synonym of homeosis by Goldschmidt (1904: 326) and Villee (1942*b*), whereas Boyden (1943: 237) makes the following distinction: "Homoeosis refers to the substitution of homotypes or serial homologues for each other, whereas heteromorphosis means the replacement of one organ by any other which need not be homotypic." Be that as it may, both words are primarily terms of genetics, but the underlying phenomena may give rise to phylogenetic changes, as does heterogenesis (*cf.* p. 335, footnote 48).

HETEROCHRONOUS AND ISOCHRONOUS MODIFICATIONS

As stated above (p. 326), neither homoplasy nor its special cases parallelism and convergence[64] as such imply anything as to contemporaneity of the similar changes in the two or more lineages concerned, and this holds true for homeomorphy as well, which is to us merely the result of a very high degree of convergence. Therefore, the time element has usually been left out of account in the preceding sections. In the three following headings, however, it assumes essential importance. The terms "heterochronous" and "isochronous," proposed by Mojsisovics (1893: 5) and adopted by Buckman (1901: 232–233) to distinguish non-contemporaneous homoeomorphs from more or less contemporaneous ones, are, therefore, best introduced at this point of our investigation. They may equally be applied to all kinds of phylogenetic modifications studied under the last three headings.

ISOCHRONOUS CONVERGENCE (OR HOMEOMORPHY) AND POLYPHYLETIC ORIGIN

As early as in 1891 (p. 362) Scott wrote the following paragraph:

. . . But if the various species of the ancestral genus may acquire the new character independently of each other (parallelism), or if the species of widely different genera may gradually assume a common

[63] Bateson (*loc. cit.*) spelled the word "homoeosis," as do Goldschmidt (1940), Villee (1942*a*,*b*), and Boyden (1943). Bridges and Dobzhansky prefer the spelling "homoösis." Our own spelling, as above, is in accordance with footnote 59, p. 339.

[64] Utterly wrong is Dacqué's (1935: 244) attempt—apparently inspired by his tendency to secure some "living space" for his ill defined "Zeitformenbildungen"—to restrict convergences to heterochronous similarities. It will be pointed out below that time signatures, as far as a certain *raison d'être* may be granted to this term, may be special (isochronous) cases of convergence as well as of parallelism.

likeness (convergence), then it is plain that such a genus is an artificial assemblage of forms of polyphyletic origin. That such parallelism of development does occur, we shall see in the next section, and there are good reasons for believing that convergence is not so rare a phenomenon as it is generally assumed to be from which it follows with great probability that many generic groups are not real expressions of relationship but artificial assemblages of similar forms.

In writing these sentences, he may have had in mind Würtenberger's and Hyatt's cases of convergence in ammonites leading to polyphyletic genera or even species (Würtenberger, 1880: 106). If we come back to Würtenberger's case of the origin of the *Ammonites mutabilis* group, repeatedly discussed above, we may well raise the question what happens in such a case if the lineages of different origin can no longer be distinguished in their offspring. Würtenberger himself (*ibid.*, 106–107) was still in a position to distinguish them by examining the inner volutions. However, if there is a trend to push the ancestral stages farther and farther back in the ontogeny, it may well be expected that such a distinction might no longer be feasible at a somewhat later evolutionary stage.

Taxonomically, the above question is rather easily answered: Once there is no more possibility of splitting up a group suspected to be composed of not truly related lineages into its components (as, e. g., Novak was able to split up the "form genus" *Scaphites*; see above, p. 338), then we have simply to accept such groups as taxonomic units such as (large) species, genera, or even higher groups,[65] according to their hierarchic rank. This is, by the way, the point where the terms "circulus" or "geologic genus," proposed for such polyphyletic groups by Bather and Ruedemann, respectively (see Grabau, 1913: 978), and von Pia's (1921) interesting considerations[66] come in.

However, all this takes care of the taxonomic problem only, the species as well as the higher taxonomic units being, *a priori*, mental concepts (Simpson, 1940: 414). The much more intriguing problem might arise whether or not isochronous convergence, in going beyond its highest degree, homeomorphy, might be able to produce, by facilitating hybridization (as far as sexually producing organisms are concerned), natural polyphyletic groups capable of propagation. However, we refrain from discussing this problem within the scope of the present paper.

TIME SIGNATURES

This is probably the youngest of all the terms dealt with in the present study. After the term "Zeitcharaktere" (= time characters) had been used by Beurlen (1929: 50), Dacqué devoted an entire section of his book of 1935 (pp. 226–251) to "Zeitformenbildung, Zeitbaustile, Zeitsignaturen" (= formation of time characters, architectural styles of the periods, time signatures), using all three of these terms indiscriminately. He attributes the appearance of "Zeitformen" to nature's predilection, at certain periods of the earth's history, for definite "architectural styles." However, critical examination of Dacqué's wordy—and mostly obscure—discussions on this subject reveals that his "Zeitformenbildung," in the wide scope given it by him, is merely another expression of the logical necessity for evolution to take place through time, or of the not less well known fact that every geologic period had living beings characteristic of this very period. There is certainly no need for special terms to express such commonplaces.

Only in a very restricted sense might Dacqué's concept be accepted to designate the repeatedly observed simultaneous appearance of certain, sometimes superficial, characters in different, mostly somewhat related groups. These are, of course, nothing but special cases of isochronous parallelism or convergence, as the case may be, although there is no serious objection to giving this phenomenon a name of its own. This purpose might best be served by using the last of Dacqué's three names, time signatures, as a descriptive, not explanatory term, rejecting the two others which seem to be too pretentious.

Schindewolf (1936: 10, 11) also seems to favor a rather restricted usage of these terms of Dacqué and to reject the latter's far-reaching inferences. He proposes a distinction between time signatures occurring within lineages rather closely related with each other or descending from common ancestors, and those occurring in

[65] Depéret (1907: 227–228) strongly doubts the theoretical probability of a "convergence absolument parfaite, allant jusqu'à la confusion des charactères genériques," except, perhaps, for organisms of a very low order such as bacilli and micrococci.

[66] He distinguishes (*ibid.*, (147)) groups evolved by parallelism from another group of the same taxonomic rank on the one hand and groups evolved by convergence from several groups of the same taxonomic rank on the other; only the latter he considers as polyphyletic; accordingly, he advocates the dissolution of compound groups evolved by convergence but not that of groups evolved by parallelism.

groups not closely related with, or even far remote from, each other. The former Schindewolf interprets as due to some common inheritance, but this conception makes it doubtful if the designation time signatures, as meant by Dacqué and as here understood, would then still be adequate. Time signatures of the second kind are believed by Schindewolf to be merely accidental and attributed to "pure convergence or homeomorphy." Since time signatures are defined above as cases of isochronous parallelism and convergence, both of which may occur between related as well as unrelated lineages, we cannot agree with Schindewolf's distinction.

Good examples of time signatures are found in the invertebrates and, among them, here again mostly in the cephalopods. Schindewolf (1936: 44) cites the "repeated and apparently independent" (translation from the German) development of triangular conchs in various series of Clymeniids of the Upper Devonian. Brinkmann (1929: 244) notices "auffällige Trachtenmoden" (= striking dress fashions) in the Cosmoceratids of the Callovian. Haas (1942*b*: 142) believes that the spiral ornamentation superimposed on the primary radial one in several genera of Dipoloceratids of the Albian, as previously noted by Spath (1922: 103, 146) and Adkins (1928: 234), which reaches its peak in the genus *Elobiceras*, might be a case in point.

Thomas (1940: 52, 53) cites the uniform change, in the early Silurian, of all graptolite families to the monograptid type as another instance, among invertebrates, "where, instead of there being later repetitions, as it were, of one of Nature's fashions [*cf.* the following heading], similar-forms are independently produced almost simultaneously." Scott (1891: 365) gave a discussion of patterns among Tertiary mammal skulls that might now be interpreted as exemplifying time signatures, but in the light of present greatly increased knowledge his generalization is questionable. We have found no clear example of time signatures among the vertebrates.

HOMEOMORPHIC RECURRENCE, ITERATION

In a non-technical way the term recurrence is applied to very different phenomena, e. g., in the fields of geology and paleontology to the return, once or several times, of "certain lithologic facies" (McKee, 1943), continental facies (Willard, 1940), or certain faunas (Williams, 1913) to the same area. With a more technical phylogenetic meaning Hyatt (1889: VIII) applied this term when he noticed "in the different genetic series of a type derived from one ancestral stock . . . a perpetual recurrence of similar forms in similar succession, which are usually called representative and often falsely classified together, though they really belong to divergent, genetic series." Dollo (1922: 216), on the other hand, insists that recurrences never happen in paleontological series.

Mojsisovics (1893: 5) suggested the term "heterochronous convergence" for the similarity he observed between unrelated, non-contemporaneous ammonites. Buckman (1895: 457), however, prefers to call this phenomenon "heterochronous homoeomorphy."

Haas (1942*a*) applied the term recurrence to the reappearance of morphologic types and evolutionary cycles of Mesozoic ammonites of an earlier geological period in a later one, equally unaware of the earlier more general statements, quoted above, and of a previous use of the same term by Depéret (1907: 235) with respect to the same phenomenon.[67]

In the cases referred to in the two preceding paragraphs and in similar ones[68] phylogenetic significance is denied to the resemblances between the heterochronous ammonite types. They may be considered typical examples of homeomorphy. As a rule, only sutural differences warrant their distinction. Such cases might, therefore, well be called ***homeomorphic recurrence.***

A somewhat related, though, at least theoretically, different phenomenon is that called "iterative Artenbildung" (iterative formation of species), described, as follows by Koken (1897: 40):

> A certain type persists through long periods almost unchanged, but becomes repeatedly the starting point for the formation of species luxuriantly radiating in all directions. These hosts of varieties and species lie one above the other, like the floors of a building, apparently without any direct genetic connection. Similar forms recur, all originating from a conservative parent stock, but not giving rise the one to the other.

A briefer description is given by Koken in 1902 (p. 13): "A persistent species puts forth, from time to time, varieties which appear in hosts, as it were, between more or less long pauses." (Translations from the German.)

[67] Dacqué (1935: 141–144) uses the German rendition "Rekurrenz" quite mistakenly for retrogressive evolution (= Eimer's, 1898: 32, phylogenetic reversion).

[68] See, e. g., Dacqué, 1921: 246, fig. 88.

The original example for this phenomenon was studied by Koken in Triassic gastropods of the *Worthenia* group; other cases were studied in pectinid pelecypods of the *Vola* type by Philippi and in craniid brachiopods of the Silurian by von Huene (Koken, *loc. cit.*).

Beurlen (1929: 52) proposes the shorter term "iteration" for the phenomenon here dealt with, describing it as the "periodically recurrent formation of the same or similar types within the same stock ('Stamm')," presupposing "no immediate homogeneousness ('Zusammengehoerigkeit'), but indirect relationship" and stating that "certain formative trends, inherent in some larger group, manifest themselves from time to time." Beurlen's shorter term is here given preference over Koken's, the more so since it is not, as is the latter, restricted to the species level and, therefore, permits of a more general application. Beurlen emphasizes the difference between iteration and convergence (roughly corresponding to the one here being made between iteration and homeomorphic recurrence), as does Schindewolf (1940: 230)[69] in describing essentially the same phenomenon as "iterative repetition of always the same evolutionary courses."

However, careful examination reveals this difference, too, to be relative only, depending on the taxonomic level of the investigation. The heterochronously homeomorphic ammonites, mentioned above, for example, certainly do not descend the one from the other and are altogether unrelated, as long as we think in terms of genera and families. Viewed, however, under the more general aspect of the order Ammonoidea as an entity, those recurrent morphologic types turn out to be just representatives of some of the "successive waves" (Spath, 1923: 33) of sculptured neritic lineages which, throughout the Mesozoic, again and again branch off from the smooth pelagic "conservative stocks" ("Konservativstämme" Salfeld) of the phylloceratids and lytoceratids, according to the hypothesis developed by Spath (1923: 14, 32, 33; 1927: 63–64; 1938: 3; 1942: 682–683) and Salfeld (1924) and shared, though in a somewhat obscure way, by Buckman (1925: 9). This phenomenon is undoubtedly, on an incomparably greater scale, essentially the same as Koken—Beurlen's iteration. Here, too, the lateral offshots are not immediately interrelated, but all of them may be derived from some common ancestral stock. Thus, the difference between homeomorphic recurrence and iteration, so clear at a lower taxonomic level, loses most of its sharpness, nay, dwindles away the more the perspective widens under which things are looked at. Just as Lankester wrote to Osborn (see Osborn, 1907*a*: 239): "Every living thing owes its properties to homogeny, that is to say, its fundamental properties to a homogeny common to it with all other living things, and as you run down group within group there must be a more specialized homogeny affecting members of smaller and smaller groups."

[69] "Auch in den Faellen, wo aehnliche Gehäuse und Skulpturtypen auf sehr verschiedenen Entwicklungsstufen des Stammes auftreten, liegt keine eigentliche Konvergenz vor, sondern vielmehr eine iterative Wiederholung stets gleicher Entwicklungsabläufe. Wir haben also hier eine im morphologischen Sinne parallele Entwicklung vor uns, die in zeitlichem Nacheinander und auf einer jeweils höheren Grundlage erfolgt."

SUMMARY

Owen's (special) homology should be restricted to similarities between parts, organs, or structures of different organisms attributable to common ancestry; homogeny (Lankester) then becomes a synonym of homology.

Homoplasy (Lankester) brings about similarities between organisms or their parts, organs or structures, due not to common ancestry but to independent acquisition of the similar characters. Even where this independent acquisition may be attributed to some latent or potential predisposition inherited by both or all lines concerned from a common ancestor (Osborn's latent or potential homology), the similarities should be considered homoplastic but not homologous. Heterology (Cope), homomorphy (Palmén), isomorphism or isomorphy (Parker, Fürbringer), homeogenesis (Eimer), and morphological equivalents (Hyatt) are considered synonyms, analogous variations (Darwin) and independent homologies (Hubb) are considered special cases of homoplasy.

Other special cases of homoplasy are convergence and parallelism, distinction between which should be based on whether or not similarity increases with evolution rather than on degree of relationship between the lines involved.

Convergence may lead to homeomorphy. The latter term ought to be restricted to similarities affecting the whole outer appearance of the homeomorphs and reaching such a degree that the one may be mistaken for the other even by a trained naturalist, unless certain internal or obscure characters are examined. Homeomor-

phy is not equivalent to, nor does it include, mimicry, but the two concepts overlap.

Neither homoplasy nor parallelism nor convergence and homeomorphy imply anything as to contemporaneity of the similar changes; all these phenomena may be either heterochronous or isochronous.

Isochronous convergence and homeomorphy may, taxonomically, lead to polyphyletic morphological genera and even higher units.

Dacqué's terms "Zeitformenbildung" and "Zeitbaustile" are rejected, his "Zeitsignaturen" (time signatures) are admitted as a descriptive, not explanatory, term to designate certain cases of isochronous parallelism or convergence.

Recurrence of morphologic types may be merely homeomorphic recurrence or attributable to Koken's "iterative Artenbildung" (iterative formation of species = Beurlen's iteration).

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HYDROGRAPHY OF MONTEREY BAY, CALIFORNIA
THERMAL CONDITIONS, PART II (1934–1937)

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I. INTRODUCTION

In the beginning of 1929 Hopkins Marine Station of Stanford University, California, began a hydrobiological survey of Monterey Bay. At that time the plan was to make this type of investigation a permanent feature in the scientific program of the Station. Two of the basic aims of the plan were, first, the examination of the hydrographic changes which occur throughout the year, and, second, to find out whether there are any short- or long-range cyclical hydrographic phenomena in this region.

Untoward happenings did not allow the fulfillment of this rather ambitious program. The collecting of field data could not be continued beyond the end of January 1938. It thus lasted only slightly more than nine years, too short a period for generalizations in the field of long-range phenomena. In addition, this type of analysis was made difficult, not to say impossible, by the fact that sometimes observations could not be made with sufficient frequency.

After five years the senior author compiled a rather extensive report on the thermal conditions (Skogsberg, 1936). In this publication the temperature changes, especially in the upper one hundred meters, in each of the first five years (1929–1933) were presented, the yearly pictures were compared with each other, and the basic features of what may be termed the typical thermal rhythm of the year were outlined.

It was found that the bay and the surrounding region within the reach of workers with our limited facilities did not lend themselves readily to hydrodynamic analysis (Skogsberg, 1936: 8) and hence work of this kind was postponed. Even so, an attempt was made to reach the best possible understanding of the water movements underlying the observed thermal variations. During two years of this period, 1932 and 1933, observations were extended to a depth of 900 meters, but the comparatively limited data did not allow any generalizations concerning the deeper strata. Nevertheless, it was clearly demonstrated that even at the deepest levels reached, changes are quite pronounced.

Besides temperatures, we also determined and studied during the first five years chlorinity, phosphate (PO_4), and silicate (SiO_2). Of the results of these studies, only parts have been published so far, viz., those pertaining to the silicate of 1932, 1933, and 1934 (Phelps, 1937). These studies show, as could be expected, that there is a distinct parallelism between the thermal and the chemical annual rhythms. "If the temperature and silicate figures be compared, one of the first points which will be noticed is the striking similarity between the general seasonal cycles in each case" (Phelps, 1937: 179).

Following the first six year period (1929–1934), health prevented the senior author from participating in the field trips and this part of the work gradually was taken over entirely by the junior author. In general the program and procedure remained the same following this change, although the sampling trips became somewhat less frequent and the number of samples less numerous. On the other hand, the chemical work was somewhat broadened (O_2 and NO_2 determinations being added on a limited scale and even NO_3 determinations being undertaken on some occasions) and, since a larger boat was available occasionally, a number of offshore expeditions were undertaken for the sake of hydrodynamic material. The treatment of the chemical and dynamic data is entirely in the hands of the junior author who, unfortunately, partly through his duties in connection with the war emergency, has been prevented from participating in the elaboration and analysis of the temperature data which form the basis of the present report. This treatment, as well as the writing of this report, hence has been the sole responsibility of the senior author.

Throughout the entire nine years the survey was an enterprise supported jointly by Stanford University and the California Department of Natural Resources. The material of this report was collected from the *Albacore* to whose permanent crew, Captain Lars Wesseth and Engineer E. Greenleaf, we wish to express our sincere thanks (Skogsberg, 1936: 4). Other persons, employed more or less temporarily, also helped on board boat, and to these too we wish to extend our appreciation.

Since the material is of the same general type and its treatment has the same self-imposed limitations, being kept very largely in the form of a descriptive account, and since the presentation is held in the same order and form as in the report by Skogsberg (1936) on the temperature conditions during the years 1929 to 1933, inclusive, the present report may be justly denoted as the second (and concluding) part of the former report.

Through these two parts—even though they together are limited to a mere nine year period—the thermal hydrographic picture of Monterey Bay may be said to have become quite well established, particularly because the results of the years 1934–1937, inclusive, clearly demonstrate that the generalizations reached on the basis of the records of the first five years were in all essentials correct. In this confirmation is probably to be found *the main value of this present report.*

In regard to the location of Monterey Bay, the positions of the observational stations, and the physiography of the bay in relation to the hydrography, reference is made to section II, page 5, of Skogsberg (1936).

As to the methods of investigation, suffice it to refer to section III, page 7, ff., of Skogsberg (1936). Concerning the material used for the present report, only a few remarks are necessary. As was noted above, after the senior author ceased participating in the observational trips, the number of observations decreased. Hence, of course, the values derived from the observations obtained during the later period of the survey are distinctly less certain than those obtained during the first five years. Data from only two stations are dealt with in the present report, viz.:

Station B:

	Number of observations	Number of visits
1934:	850	41
1935:	220	18
1936:	450	35
1937:	455	33

Total observations during 1934–1937, 1,975.

Station C:

	Number of observations	Number of visits
1934:	847	41
1935:	361	20
1936:	770	39
1937:	700	36

Total observations during 1934–1937, 2,678.

The degree of correctness of the temperature readings is ±0.1°, and the temperatures are in Centigrade.

All data concerning the upper 100 m., unless otherwise stated, were collected at station B.

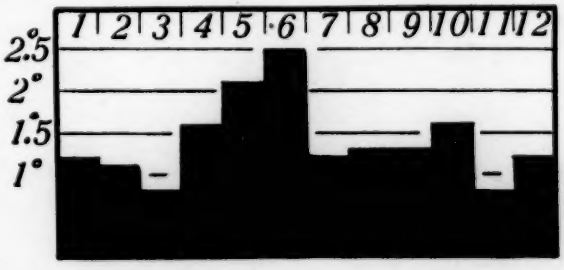

FIG. 1. Average amplitude of monthly thermal variation throughout the year, at surface, 1934–1937. Station B.

II. MONTHLY THERMAL CONDITIONS IN THE UPPER ONE HUNDRED METERS

As will be seen from Skogsberg (1936: 14–15), an analysis of the temperature conditions in 1929–1933 yielded among others the following results:

1. "While the monthly average temperatures for this layer may exhibit relatively large differences from one year to another, the vertical thermal distribution is comparatively stable for the individual months, each month having a fairly pronounced pattern."

2. This pattern shows a distinct seasonal progression, expressed mainly by the thermal gradients.

3. "The amplitudes of thermal variation at and near the surface also exhibit a certain seasonal trend, although in a more irregular and obscure manner."

4. Although the seasonal progression of the thermal gradients simulates strikingly the one characteristic of temperate regions, it is brought forth in a nearly opposite manner.

A study of the temperatures at station B during 1934–1937 revealed similarities with those of 1929–1933 so strong as to justify the statement that the conditions during 1929–1933 were quite typical and characteristic of this region. The only notable difference of a general nature which we found was that there was no distinct rhythm in the amplitudes of thermal variations at and near the surface. By combining the four years, results were obtained which are expressed in figure 1. This graph shows quite plainly the absence of a distinct rhythm. It may be added that when the individual years were examined, they showed irregularities so pronounced and variable from year to year that we decided not to present them in the form of another graph. Considering the uncertainty of the indications found during 1929–1933, it may be said with a fair justification that a clear rhythm of this kind is absent in these waters.

The monthly gradients are shown by a single graph (fig. 2) representing the average conditions for 1934–1937, both from the surface to 50 m. and from the surface to 100 m. Especially the line giving the gradient for 0–50 m. shows clearly the same pronounced seasonal rhythm as in 1929–1933. Since the individual years exhibit the same consistency as in figures 4–6 of Skogsberg (1936) it was considered unnecessary to present them individually for the period of 1934–1937.

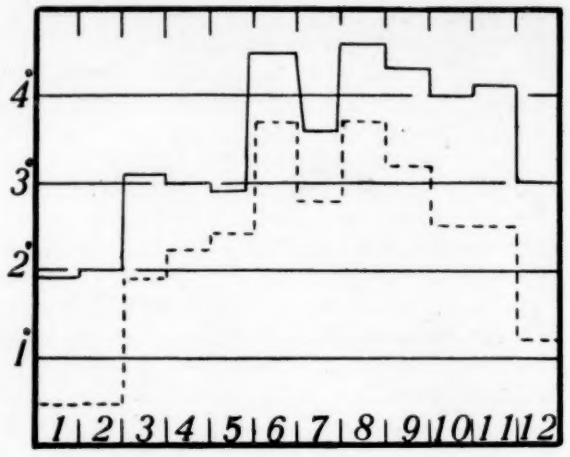

FIG. 2. Average monthly thermal gradients, 1934–1937. Station B. Continuous line is 0–100 m.; broken line is 0–50 m.

Concerning the presentation of the new material, it should also be noted that, in order to facilitate comparison, the language, as well as the order in which the material is arranged, is as similar as possible to Skogsberg (1936: 15 ff.). Considering the great similarities between 1929–1933 and 1934–1937, the following presentation is extremely condensed, it being taken for granted that it will be read in conjunction with the 1936 account. The comparative oceanographer will find the monthly averages for 1934–1937 in an appendix at the end of this report (appendix table 1).

January.—This was a month of very low thermal gradients. The lowest one was found in 1935 when on one occasion the temperature was identical throughout the upper 70 m. and the decrease from the surface to 100 m. was only 0.4° C. The average gradients for this month were as follows from 1934 to 1937:

	Surf., 50 m.	Diff.	Surf., 100 m.	Diff.
1934	11.7°–11.0°	0.7°	11.7°–10.2°	1.5°
1935	12.4°–12.2°	0.2°	12.4°–10.4°	2.0°
1936	11.6°–10.6°	1.0°	11.6°– 9.6°	2.0°
1937	12.2°–11.7°	0.5°	12.2°–10.1°	2.1°
Average	12.0°–11.5°	0.5°	12.0°–10.1°	1.9°

The monthly average temperatures varied but slightly during these years:

	1934	1935	1936	1937
0–50 m.....	11.4°	12.4°	11.1°	12.1°
50–100 m.....	10.6°	11.1°	10.1°	10.9°

The total amplitudes of thermal variation for 1934–1937 were 2.3° (13.2°–10.9°), at the surface; 3.7° (13.1°–9.4°), at 50 m.; and 3.0° (12.2°–9.2°), at 100 m. For each of the years, the following values of thermal variation were established:

	Surf.	50 m.	100 m.
1934	1.1°(12.2°–11.1°)	2.1°(12.0°– 9.9°)	1.8°(11.1°–9.3°)
1935	0.8°(12.8°–12.0°)	1.1°(12.7°–11.6°)	3.0°(12.2°–9.2°)
1936	0.4°(11.8°–11.4°)	0.7°(11.0°–10.3°)	0.8°(10.0°–9.2°)
1937	2.3°(13.2°–10.9°)	3.7°(13.1°– 9.4°)	2.0°(10.9°–8.9°)
Average	1.2°	1.9°	1.9°

For the average temperatures of 0–50 m., these years showed the following amplitudes: 1.6°, 0.9°, 0.5°, and 2.6° (average, 1.4°); the amplitudes for 50–100 m. were 2.0°, 2.6°, 1.0°, and 2.6° (average 2.1°).

The winter cooling of the surface water was never strong enough to be evident in the average monthly surface temperature (hence for the month less than 0.1°). Only on one occasion could it be traced to a depth of 5 m., where the temperature was 0.1° less than at 10 m. (Observations were made between 8 and 9 A.M.)

A comparison with 1929–1933 shows extraordinary similarities in regard to the average monthly gradient for 0–50 m. and total amplitudes of variation at the surface and 50 m.; variations did not have the same clear tendency to increase with depth.

February.—No tangible differences from the conditions just described developed during this month. The average gradients were as follows:

	Surf., 50 m.	Diff.	Surf., 100 m.	Diff.
1934	12.4°–11.7°	0.7°	12.4°– 9.8°	2.6°
1935	12.2°–11.3°	0.9°	12.2°– 9.6°	2.6°
1936	12.4°–12.2°	0.2°	12.4°–10.6°	1.8°
1937	10.7°–10.7°	0.0°	10.7°– 9.8°	0.9°
Average	11.9°–11.4°	0.5°	11.9°– 9.9°	2.0°

The monthly average temperatures varied as follows:

	1934	1935	1936	1937
0–50 m.....	12.1°	12.0°	12.4°	10.9°
50–100 m.....	10.9°	10.5°	11.4°	10.2°

The total amplitudes of thermal variation were 3.0° (13.2°–10.2°), at the surface; 2.8° (12.8°–10.0°), at 50 m.; and 2.0° (11.0°–9.0°), at 100 m. The monthly variations at representative levels were as follows:

	Surf.	50 m.	100 m.
1934	1.4°(13.2°–11.8°)	2.1°(12.8°–10.7°)	0.8°(10.1°– 9.3°)
1935	1.7°(12.8°–11.1°)	2.2°(12.2°–10.0°)	1.2°(10.2°– 9.0°)
1936	0.3°(12.5°–12.2°)	0.7°(12.6°–11.9°)	0.8°(11.0°–10.2°)
1937	0.8°(11.0°–10.2°)	0.5°(10.9°–10.4°)	0.7°(10.1°– 9.4°)
Average	1.1°	1.4°	0.9°

For the average temperatures of 0–50 m., these four years showed the following amplitudes: 1.7°, 1.5°, 0.5°, and 0.2° (average, 1.0°); for 50–100 m., they were 1.2°, 1.9°, 0.0°, and 0.8° (average, 1.0°).

In 1936 winter cooling caused the average surface temperature of the month to be 0.1° less than the temperature at 5 m.; and on one occasion (February 8, 1937) there was a thin layer of muddy rain water which was not less than 0.9° cooler than the underlying pure sea water.

When compared with conditions during 1929–1933, the temperatures of February 1934–1937 showed remarkable similarities, but the variations did not, as a rule, increase with depth.

March.—As during the period of 1929–1933, this month marked the beginning of the seasonal progression characterized particularly by the increase in the thermal gradient caused by the progressive lowering of the temperatures in the deeper strata. The monthly thermal gradients showed the following averages:

	Surf., 50 m.	Diff.	Surf., 100 m.	Diff.
1934	13.2°–10.3°	2.9°	13.2°–9.1°	4.1°
1935	11.7°–10.2°	1.5°	11.7°–9.1°	2.6°
1936	12.6°–10.3°	2.3°	12.6°–9.4°	3.2°
1937	11.7°–10.6°	1.1°	11.7°–9.2°	2.5°
Average	12.3°–10.4°	1.9°	12.3°–9.2°	3.1°

The monthly averages were as follows:

	1934	1935	1936	1937
0–50 m.....	11.7°	11.1°	11.1°	11.2°
50–100 m.....	9.5°	9.5°	9.7°	9.8°

The total amplitudes of thermal variation were 2.9° (14.0°–11.1°), at the surface; 1.3° (11.2°–

9.9°), at 50 m.; and 0.7° (9.5°–8.8°), at 100 m. The monthly amplitudes of variation were:

	Surf.	50 m.	100 m.
1934	1.4°(14.0°–12.6°)	0.7°(10.6°– 9.9°)	0.6°(9.4°–8.8°)
1935	0.1°(11.7°–11.6°)	0.4°(10.4°–10.0°)	0.3°(9.3°–9.0°)
1936	0.8°(13.0°–12.2°)	0.2°(10.4°–10.2°)	0.2°(9.5°–9.3°)
1937	0.8°(11.9°–11.1°)	0.9°(11.2°–10.3°)	0.7°(9.5°–8.8°)
Average	0.8°	0.6°	0.5°

For the average temperatures of 0–50 m., these years showed the following amplitudes: 0.8°, 0.4°, 0.3°, 0.9° (average, 0.6°); for 50–100 m., they were 0.7°, 0.2°, 0.2°, 1.0° (average, 0.5°).

No winter cooling was observed in the surface layers. It should be noted that the low amplitudes of variation undoubtedly are in part apparent and due to scarcity of data.

April.—On the whole, the deeper layers continued to show a decline of temperature. The increase in the average monthly gradient was slight in the upper 50 m.; and between 50 m. and 100 m. the gradient was nearly unaltered. The monthly average thermal gradients were as follows:

	Surf., 50 m.	Diff.	Surf., 100 m.	Diff.
1934	11.6°–9.3°	2.3°	11.6°–8.7°	2.9°
1936	11.6°–9.5°	2.1°	11.6°–8.6°	3.0°
1937	11.0°–9.0°	2.0°	11.0°–8.1°	2.9°
Average	11.5°–9.3°	2.2°	11.5°–8.5°	3.0°

The monthly averages showed the following values:

	1934	1936	1937
0–50 m.....	10.3°	10.4°	10.1°
50–100 m.....	8.9°	8.9°	8.4°

The total amplitudes of variation of temperature were 2.4° (12.7°–10.3°), at the surface; 1.6° (10.1°–8.5°), at 50 m.; and 0.9° (9.0°–8.1°), at 100 m. The monthly amplitudes of variation were:

	Surf.	50 m.	100 m.
1934	1.8°(12.7°–10.9°)	1.2°(10.1°–8.9°)	0.4°(9.0°–8.6°)
1936	2.1°(12.4°–10.3°)	0.4°(9.7°–9.3°)	0.3°(8.7°–8.4°)
1937	0.8°(11.4°–10.6°)	1.0°(9.5°–8.5°)	0.0°(8.1°–8.1°)
Average	1.6°	0.9°	0.3°

The layer of 0–50 m. exhibited the following amplitudes during these three years, 1.3°, 1.0°, and 0.2° (average, 0.8°); and the layer from 50–100 m., 0.5°, 0.3°, and 0.3° (average, 0.4°).

By and large, April of these three years shows a rather pronounced similarity with this month of 1929–1933. Especially noteworthy is that the average temperatures for the month are consistently lower than those of March.

May.—This month showed a striking similarity with April. Contrary to during 1929–1933, there was no decided increase in the gradient of this month during 1934–1937. Summer warming was still hidden by circulatory phenomena and the deeper strata remained cold. The monthly average gradients were as follows:

	Surf., 50 m.	Diff.	Surf., 100 m.	Diff.
1934	12.6°–9.4°	3.2°	12.6°–8.9°	3.7°
1936	11.7°–9.2°	2.5°	11.7°–8.6°	3.1°
1937	10.9°–8.8°	2.1°	10.9°–8.4°	2.5°
Average	11.5°–9.1°	2.4°	11.5°–8.6°	2.9°

The monthly averages were as follows:

	1934	1936	1937
0–50 m.....	10.6°	10.2°	9.7°
50–100 m.....	9.3°	8.9°	8.5°

The total amplitudes of monthly variation were 4.5° (14.8°–10.3°), at the surface; 1.3° (9.7°–8.4°), at 50 m.; and 1.0° (9.1°–8.1°), at 100 m. The monthly amplitudes of variation were:

	Surf.	50 m.	100 m.
1934	4.5°(14.8°–10.3°)	0.6°(9.7°–9.1°)	0.4°(9.1°–8.7°)
1936	0.8°(12.1°–11.3°)	0.2°(9.3°–9.1°)	0.3°(8.8°–8.5°)
1937	1.1°(11.6°–10.5°)	1.2°(9.6°–8.4°)	0.8°(8.9°–8.1°)
Average	2.1°	0.7°	0.5°

For the average temperatures of 0–50 m., these years showed the following amplitudes; 1.5°, 0.6°, 1.0° (average, 1.0°); for 50–100 m., they were 0.7°, 0.2°, 0.7° (average, 0.5°).

June.—The increase in the thermal gradient was pronounced throughout the entire upper 100 m., reaching for all practical purposes the annual maximum. It was brought forth by the warming of the superficial strata and by the fact that the deeper strata remained cool. The monthly average gradients were as follows:

	Surf., 50 m.	Diff.	Surf., 100 m.	Diff.
1934	12.3°–9.2°	3.1°	12.3°–8.6°	3.7°
1936	13.7°–9.3°	4.4°	13.7°–8.5°	5.2°
1937	13.2°–9.6°	3.6°	13.2°–8.7°	4.5°
Average	13.1°–9.4°	3.7°	13.1°–8.6°	4.5°

The monthly averages were as follows:

	1934	1936	1937
0–50 m.....	10.4°	10.9°	10.8°
50–100 m.....	8.9°	8.8°	9.1°

The total amplitudes of monthly variation were 5.8° (16.0°–10.2°), at the surface; 1.3° (10.2°–8.9°), at 50 m.; and 1.0° (9.2°–8.2°), at 100 m. The monthly amplitudes of variation were:

	Surf.	50 m.	100 m.
1934	1.1°(12.7°–11.6°)	0.3°(9.3°–9.0°)	0.7°(8.9°–8.2°)
1936	5.8°(16.0°–10.2°)	0.8°(9.7°–8.9°)	0.7°(8.9°–8.2°)
1937	0.7°(13.6°–12.9°)	1.2°(10.2°–9.0°)	0.8°(9.2°–8.4°)
Average	2.5°	0.8°	0.7°

The amplitudes of the average temperatures for 0–50 m. were 0.4°, 2.2°, and 0.9° (average, 1.2°) for the respective years; and for 50–100 m., 0.4°, 0.8°, and 0.8° (average, 0.7°).

July.—The most striking phenomenon of this month, in two out of three years, was the sudden change in the average thermal gradient, which dropped below what may be termed the "typical" summer gradient (fig. 2). The deeper layers showed some warming but still remained quite cool. The monthly average gradients were as follows:

	Surf., 50 m.	Diff.	Surf., 100 m.	Diff.
1934	12.7°– 9.9°	2.8°	12.7°–9.1°	3.6°
1936	11.4°– 9.1°	2.3°	11.4°–8.6°	2.8°
1937	13.4°–10.2°	3.2°	13.4°–9.2°	4.2°
Average	12.6°– 9.8°	2.8°	12.6°–9.0°	3.6°

The monthly averages were as follows:

	1934	1936	1937
0–50 m.....	10.8°	9.9°	11.5°
50–100 m.....	9.4°	8.8°	9.6°

The total amplitudes of monthly variation were 3.7° (14.6°–10.9°), at the surface; 2.1° (11.2°–9.1°), at 50 m.; and 0.9° (9.7°–8.8°), at 100 m. The monthly amplitudes of variation were:

	Surf.	50 m.	100 m.
1934	0.7°(13.0°–12.3°)	0.7°(10.2°–9.5°)	0.5°(9.3°–8.8°)
1936	1.0°(11.9°–10.9°)	0.2°(9.2°–9.0°)	0.5°(8.9°–8.4°)
1937	1.9°(14.6°–12.7°)	2.1°(11.2°–9.1°)	0.9°(9.7°–8.8°)
Average	1.2°	1.0°	0.6°

The amplitudes of the average temperatures for 0–50 m. were 0.8°, 0.6°, 1.5° (average, 1.0°); and for 50–100 m., 0.9°, 0.2°, 1.3° (average, 0.8°), respectively.

August.—In this month the average thermal gradient returned to its "normal" type. Warming of the superficial layers was, as a rule, quite evident; and the cold water in the deeper strata became increasingly rare. The monthly average gradients were as follows:

	Surf., 50 m.	Diff.	Surf., 100 m.	Diff.
1934	13.2°– 9.9°	3.3°	13.2°– 9.2°	4.0°
1936	14.4°–10.8°	3.6°	14.4°–10.0°	4.4°
1937	14.5°–10.3°	4.2°	14.5°– 9.3°	5.2°
Average	14.0°–10.3°	3.7°	14.0°– 9.4°	4.6°

The monthly averages were:

	1934	1936	1937
0–50 m.....	11.1°	12.4°	11.9°
50–100 m.....	9.5°	10.3°	9.8°

The total amplitudes of monthly variation were 3.1° (14.8°–11.7°), at the surface; 2.0° (11.2°–9.2°), at 50 m.; and 1.7° (10.4°–8.7°), at 100 m. The monthly amplitudes of variation were:

	Surf.	50 m.	100 m.
1934	2.6°(14.3°–11.7°)	1.4°(10.6°– 9.2°)	1.2°(9.9°–8.7°)
1936	0.4°(14.6°–14.2°)	0.9°(11.2°–10.3°)	0.8°(10.4°–9.6°)
1937	0.9°(14.8°–13.9°)	0.2°(10.4°–10.2°)	0.5°(9.6°–9.1°)
Average	1.3°	0.8°	0.8°

The amplitudes of the average temperatures for 0–50 m. were 1.3°, 1.1°, and 1.0° (average, 1.1°); and for 50–100 m., 0.9°, 0.7°, and 0.4° (average, 0.7°), respectively.

September.—The decline of the monthly average gradient was evident, despite the fact that the surface waters were nearly consistently warm. In the period of 1934–1937 this month thus did not occupy a peak position quite so distinctly as during 1929–1933. At the same time it resembled this month of the latter period quite strikingly. The monthly average gradients were as follows:

	Surf., 50 m.	Diff.	Surf., 100 m.	Diff.
1934	14.0°–10.9°	3.1°	14.0°– 9.6°	4.4°
1935	14.0°–10.2°	3.8°	14.0°– 9.6°	4.4°
1936	14.6°–11.4°	3.2°	14.6°–10.0°	4.6°
1937	13.1°–10.1°	3.0°	13.1°– 9.9°	3.2°
Average	14.1°–10.9°	3.2°	14.1°– 9.8°	4.3°

The monthly thermal averages were:

	1934	1935	1936	1937
0–50 m.	12.1°	12.0°	12.7°	11.2°
50–100 m.	10.1°	9.9°	10.6°	10.0°

The total amplitudes of monthly variation for 1934–1937 were 2.5° (15.6°–13.1°), at the surface; 2.2° (12.2°–10.0°), at 50 m.; and 1.5° (10.6°–9.1°), at 100 m. The monthly amplitudes of variation were:

	Surf.	50 m.	100 m.
1934	1.6°(14.9°–13.3°)	1.7°(11.9°–10.2°)	1.5°(10.6°–9.1°)
1935	0.5°(14.3°–13.8°)	0.5°(10.5°–10.0°)	0.2°(9.7°–9.5°)
1936	1.9°(15.6°–13.7°)	2.0°(12.2°–10.2°)	0.3°(10.1°–9.8°)
Average	1.3°	1.4°	0.7°

The monthly amplitudes of the average temperatures for 0–50 m. were 2.3°, 0.5°, and 1.6° (average, 1.5°); and for 50–100 m., 1.5°, 0.3°, and 0.8° (average, 0.9°), respectively.

October.—Although the thermal gradient continued its seasonal decline and the deeper waters, on the average, showed a slight increase in temperature, this month exhibited a striking similarity to September. The warm surface water continued to characterize the bay. The monthly average gradients were as follows:

	Surf., 50 m.	Diff.	Surf., 100 m.	Diff.
1934	13.7°–11.7°	2.0°	13.7°– 9.8°	3.9°
1935	13.8°–11.1°	2.7°	13.8°–10.0°	3.8°
1936	14.8°–11.9°	2.9°	14.8°–10.1°	4.7°
1937	14.4°–11.2°	3.2°	14.4°–10.5°	3.9°
Average	14.0°–11.5°	2.5°	14.0°–10.0°	4.0°

The monthly thermal averages were:

	1934	1935	1936	1937
0–50 m.	12.6°	12.5°	12.7°	12.4°
50–100 m.	10.7°	10.6°	10.6°	10.8°

The total amplitudes of monthly variation for 1934–1937 were 3.0° (15.2°–12.2°), at the surface; 1.3° (12.2°–10.9°), at 50 m.; and 0.9° (10.5°–9.6°), at 100 m. The monthly amplitudes of variations were:

	Surf.	50 m.	100 m.
1934	1.7°(14.5°–12.8°)	1.1°(12.2°–11.1°)	0.5°(10.1°–9.6°)
1935	2.5°(14.7°–12.2°)	0.5°(11.4°–10.9°)	0.9°(10.5°–9.6°)
1936	0.7°(15.2°–14.5°)	0.6°(12.2°–11.6°)	0.5°(10.3°–9.8°)
Average	1.6°	0.7°	0.6°

The monthly amplitudes of the average temperatures for 0–50 m. were 1.6°, 1.0°, and 0.5° (average, 1.0°); and for 50–100 m., 0.8°, 1.2°, and 0.5° (average, 0.8°), respectively.

November.—In three out of four years the hydrographic conditions of October remained largely unchanged during November. (The fourth appeared to have been characterized by distinct cooling; but the data were too few to allow such a statement.) This was strikingly contrary to the development in 1929–1933 in which years there was a characteristic approach to the winter conditions. The monthly average gradients were as follows:

	Surf., 50 m.	Diff.	Surf., 100 m.	Diff.
1934	13.8°–11.5°	2.3°	13.8°– 9.9°	3.9°
1935	12.1°– 9.6°	2.5°	12.1°– 9.5°	2.6°
1936	14.5°–12.2°	2.3°	14.5°–10.4°	4.1°
1937	15.3°–12.3°	3.0°	15.3°– 9.9°	5.4°
Average	14.1°–11.6°	2.5°	14.1°–10.0°	4.1°

The monthly thermal averages were:

	1934	1935	1936	1937
0–50 m.....	13.0°	11.0°	13.6°	13.9°
50–100 m.....	10.5°	9.6°	11.2°	10.6°

The total monthly amplitudes of variation for 1934–1937 were 3.2° (15.3°–12.1°), at the surface; 2.8° (12.4°–9.6°), at 50 m.; and 2.0° (10.5°–9.5°), at 100 m. The monthly amplitudes of variation were:

	Surf.	50 m.	100 m.
1934	0.5°(14.1°–13.6°)	1.5°(12.4°–10.9°)	0.8°(10.3°– 9.5°)
1936	1.1°(15.0°–13.9°)	0.9°(12.6°–11.7°)	0.3°(10.5°–10.2°)
Average	0.8°	1.2°	0.6°

The monthly amplitudes of the average temperatures for 0–50 m. were 1.3° and 1.1° (average, 1.2°); and for 50–100 m., 0.7° and 0.8° (average, 0.8°), respectively.

December.—By and large the temperatures of December 1934–1937 showed a striking resemblance to those during this month of 1929–1933. Perhaps the most striking seasonal feature was the abrupt decrease in the average monthly gradient which in a couple of years was brought slightly below the maximum monthly average gradient ever recorded for January. The monthly average gradients were as follows:

	Surf., 50 m.	Diff.	Surf., 100 m.	Diff.
1934	13.2°–11.6°	1.6°	13.2°–10.0°	3.2°
1936	14.1°–13.2°	0.9°	14.1°–11.5°	2.6°
1937	13.7°–12.8°	0.9°	13.7°–10.2°	3.5°
Average	13.7°–12.5°	1.2°	13.7°–10.7°	3.0°

The monthly thermal averages were:

	1934	1936	1937
0–50 m.....	12.6°	13.7°	13.4°
50–100 m.....	10.6°	12.3°	11.5°

The total monthly amplitudes of variation for 1934–1937 were 2.1° (14.3°–12.2°), at the surface; 3.5° (13.6°–10.1°), at 50 m.; and 2.9° (12.0°–9.1°), at 100 m. The monthly amplitudes of variation were:

	Surf.	50 m.	100 m.
1934	1.8°(14.0°–12.2°)	2.4°(12.5°–10.1°)	1.4°(10.5°– 9.1°)
1936	0.5°(14.3°–13.8°)	0.7°(13.6°–12.9°)	1.2°(12.0°–10.8°)
Average	1.2°	1.6°	1.3°

The monthly amplitudes of the average temperatures for 0–50 m. were 2.5° and 0.7° (average, 1.6°); and for 50–100 m., 1.7° and 0.9° (average, 1.3°), respectively. Winter cooling of the surface water was observed on a number of occasions: at one time the temperature at 10 m. was 0.1° lower than at 15 m.

III. ANNUAL THERMAL CONDITIONS IN THE UPPER ONE HUNDRED METERS

The material used in the following accounts was collected entirely at station B. The method employed in graphs 3–7 which present this material is the same as in Skogsberg (1936: 40), i. e., black indicates 8°, oblique crosshatching with dots indicates 9°, etc., until blank spaces indicate 15° or higher. Temperatures higher than 15° were so rare that it was decided not to distinguish them except by lines of distributional limitation. Temperatures were sometimes read at each 5 m. and sometimes only at each 10 m. level. When the full degrees were located between these levels, "their positions in the graphs were estimated to the nearest meter by interpolation carried out on the assumption that the thermal changes were progressing at a uniform rate. Of course, this assumption is arbitrary and far from correct in all cases. However, the errors introduced in this manner are undoubtedly nearly always too small to influence the graphs to an appreciable degree" (Skogsberg, 1936: 40). The number of temperature readings throughout the year was, as already stated, rather limited. It can easily be distinguished by the bends in the curves. It is fully realized that this limitation distinctly decreases the accuracy of the accounts, but at the same time it is strongly felt that the number is sufficient to allow the unfolding of the annual rhythm.

CONDITIONS IN 1934 (FIG. 3)

In this year, the upwelling period, as indicated by the 9° water, began in the middle of February and continued uninterruptedly until the middle of September. It is true that water of this temperature had entered the bay even in a large body during the latter part of January, and that it could be found above one hundred meters also

during the last three months of the year, but these visits were of comparatively short duration. The typical upwelling water, viz. of 8°, came into the bay in the form of comparatively short-lived waves, none of which was of pronounced dominance, from March until the beginning of August. However, the period from the beginning of April to the end of June was particularly characterized by the presence of these waves. Water of 10° was present above the 100 m. level uninterruptedly throughout the year, coming closest to the surface during the main upwelling period when, on two occasions, in April and May, it was recorded at the very surface. Water of 11° was found at the surface only during the first eight months of the year, in which period it was forced down on a number of occasions by the inflow of warmer water which penetrated quite deeply at one time in February. In the last four months of the year, water of 12° or warmer tended to dominate the upper 50 m., although its history was quite irregular.

CONDITIONS IN 1935 (FIG. 4)

In this year we were unfortunately forced to remain ashore from March 11 to September 12. During the last seven weeks of the year, collecing of data was also made impossible. In other words, for all practical purposes nearly the entire upwelling period passed without our being able to keep any records. However, despite the paucity of our observations, there is enough evidence to indicate that the annual rhythm followed the usual pattern. Upwelling, as marked by the 9° water, began in the middle of February and continued, possibly uninterruptedly, to the end of September; in other words, it had about the same duration as in 1934. Water of 9°, however, came in earlier than the middle of February and was found, this time in large bulk, in the beginning of November. During January and February, 12° water loomed large, on one occasion, in the middle of January, even filling the bay to a depth of slightly more than 100 m. The "Oceanic" water appears to have come into the bay comparatively late, i. e., in October, and its bulk, as well as its temperature, was moderate, the 13° water extending not even to the 30 m. level.

CONDITIONS IN 1936 (FIG. 5)

Although the 9° water was present above the 100 m. level during January (unfortunately, owing to lack of data, we do not know for how long), the real influx of this water began first in the first part of March, after which it continued to be important until the beginning of August. Just before leaving, it even reached as high as to about the 10 m. level. Following the end of the main upwelling wave, 9° water appeared only as small, decreasing pulses during the period from the middle of August to the middle of October. The characteristic upwelling water of 8° appeared above the 100 m. level as a continuous pulse from the beginning of April to the end of July, but as usual it was not uniform but made up of a series of pulses, one of which rose above the 50 m. level (and of June). Water of 10° appears to have been present above the 100 m. level throughout the entire year except for about a month near the end of the year, reaching the surface on two occasions, viz., in the beginning of April and for some time at the end of June and the beginning of July. Water of 11° did not occur at the surface after the first week of August. Just before upwelling began, there was a fairly large influx of 12° water; and in the first three weeks of June, there was a moderate influx of oceanic water. The last five months of the year were characterized by comparatively warm water. On two occasions 12° water penetrated down to the 100 m. level (in December) and the surface layers were often characterized by water of 14°, indicating that the Oceanic Period of this year was of unusual duration and strength.

CONDITIONS IN 1937 (FIG. 6)

As usual, the large upwelling wave, as indicated by 9° water, began in the middle of February. This water was present above the 100 m. level continuously until the beginning of October, reaching its highest level towards the end of May when it came within about 10 m. of the surface. In November there was a slight pulse of this water, reaching only to about the 95 m. level. It should also be noted that during the latter half of January a short but high pulse of this water entered the bay, a pulse that contained even a small amount of 8° water, a very rare phenomenon, indeed, for this time of the year. The 8° water loomed large during April and May, reaching at one time, in the middle of May, even above the 30 m. level. During June and July there were successively smaller pulses of 8° water, the one at the end of July barely reaching above the 100 m. level. Water of 10°

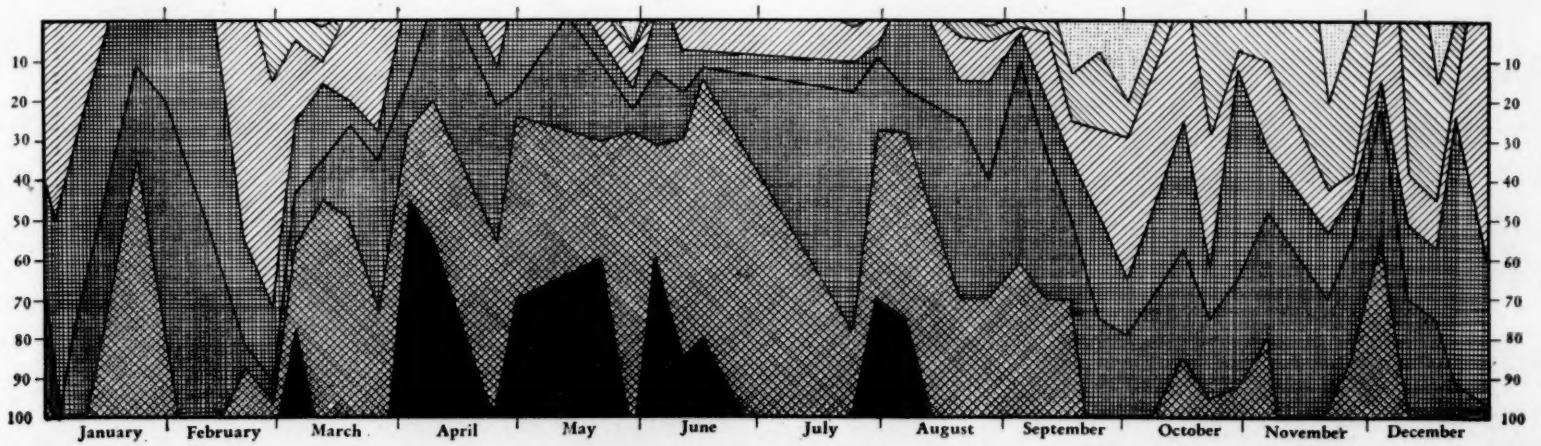

FIG. 3. Thermal conditions in the upper 100 meters, at station B, in 1934. For interpretation of symbols used, see p. 357. For description, see p. 357.

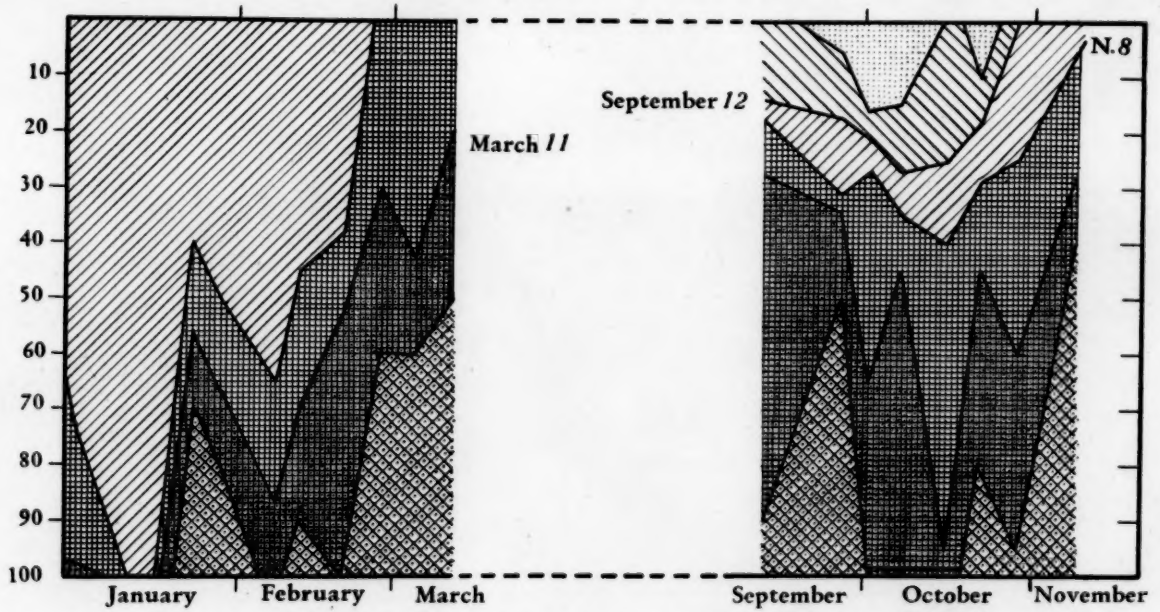

FIG. 4. Thermal conditions in the upper 100 meters, at station B, in 1935. For interpretation of the symbols, see p. 357. For description, see p. 358.

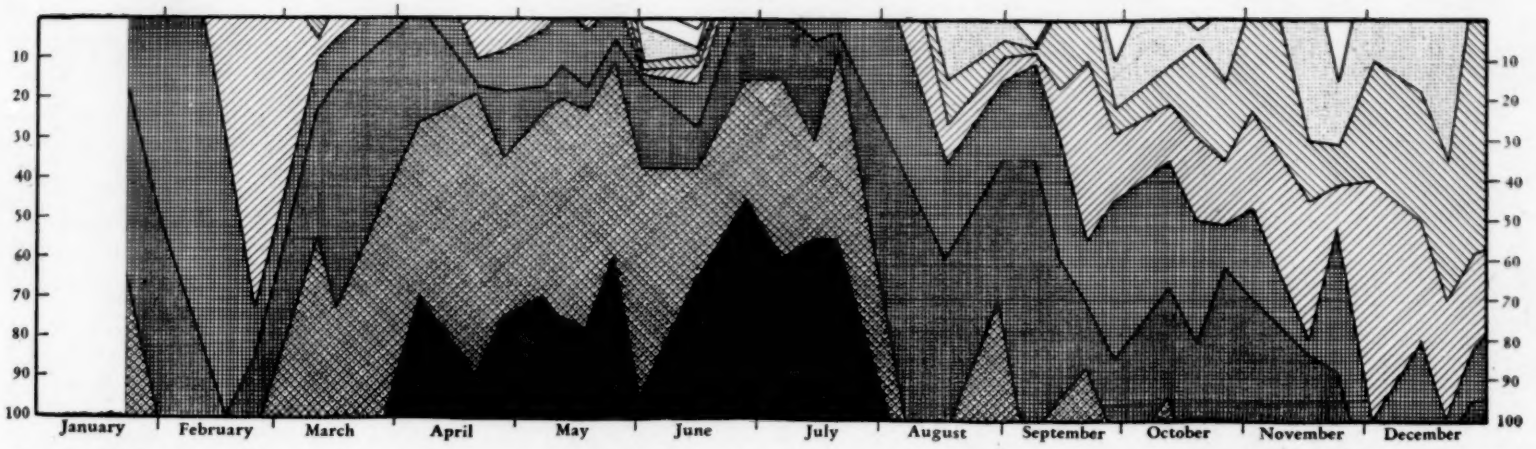

FIG. 5. Thermal conditions in the upper 100 meters, at station B, in 1936. For interpretation of the symbols, see p. 357. For description, see p. 358.

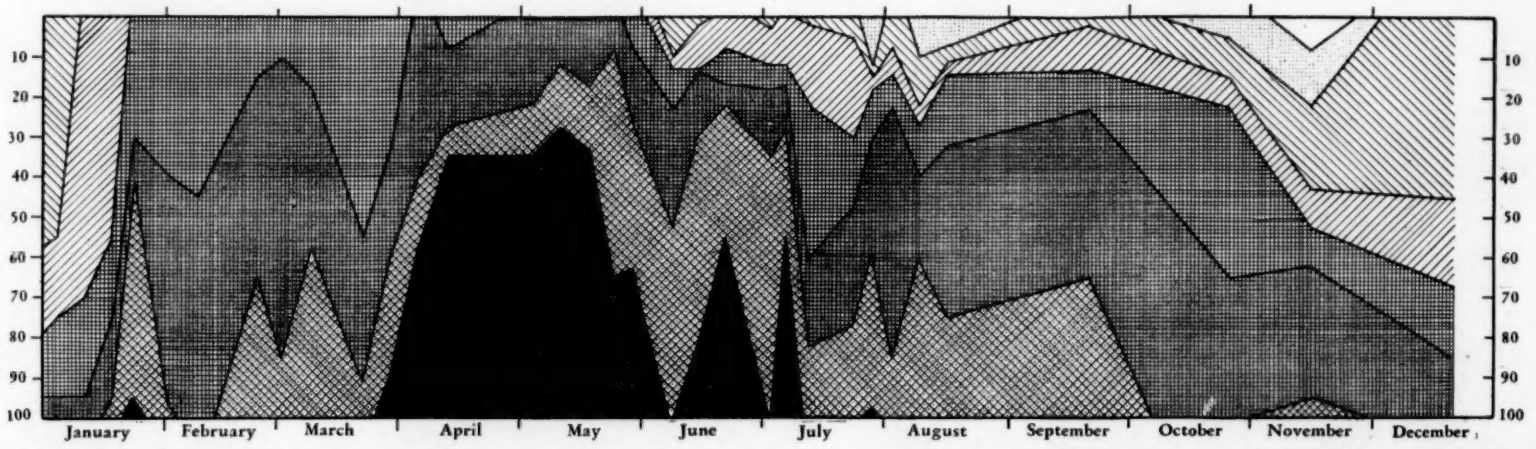

FIG. 6. Thermal conditions in the upper 100 meters, at station B, in 1937. For interpretation of the symbols, see p. 357. For description, see p. 358.

was present above the 100 m. level throughout the year, reaching the surface practically throughout April and May. As far as the 11° water is concerned, suffice it to note that, while it dominated the superficial strata from the latter part of January to the first part of April, it became, generally speaking, ever farther removed from the surface during the latter half of the year, never coming to the surface from the first week of June. The warm water (12°–13°) which dominated the upper 75 m. during the last part of 1936 was also very bulky in the first part of January; and it occupied an increasing volume in October–December of 1937, the oceanic water apparently lingering in the upper strata of the bay for a prolonged period, just as in 1936, although it was not quite so clearly marked in that year.

NORMAL ANNUAL RHYTHM IN THE UPPER ONE HUNDRED METERS (FIG. 7)

In the discussion of the annual thermal conditions presented by Skogsberg (1936: 54) it was noted that a general inspection of the five graphs representing the individual years from 1929 to 1933, inclusive, indicated two fundamental conditions: first, that there is in this region a distinct, annual rhythm in the distribution of the temperatures and, secondly, that "to a different extent in different years this rhythm is warped and obscured by secondary, interfering phenomena." Considering the fact that the irregularities caused by the secondary forces appeared to be distributed at random, it was concluded that a combination of these five curves would tend to bring forth the fundamental rhythm more clearly by smoothing the irregularities. Of course, complete smoothness was not expected because of the small number of years examined. The results proved this reasoning to be sound; the rhythm did come out with remarkable clarity, indeed, even to such an extent as to suggest that an additional free-hand smoothing would be justifiable.

The secondary smoothing resulted in figure 13 of Skogsberg (1936). It indicated that in each year there are three hydrographic periods, viz., the "Davidson Current Period," from the middle of November to the middle of February, the "Upwelling Period," from the middle of February to the latter part of August, and, finally, the "Oceanic Period," filling the remaining portion of the year. The Davidson Current period was

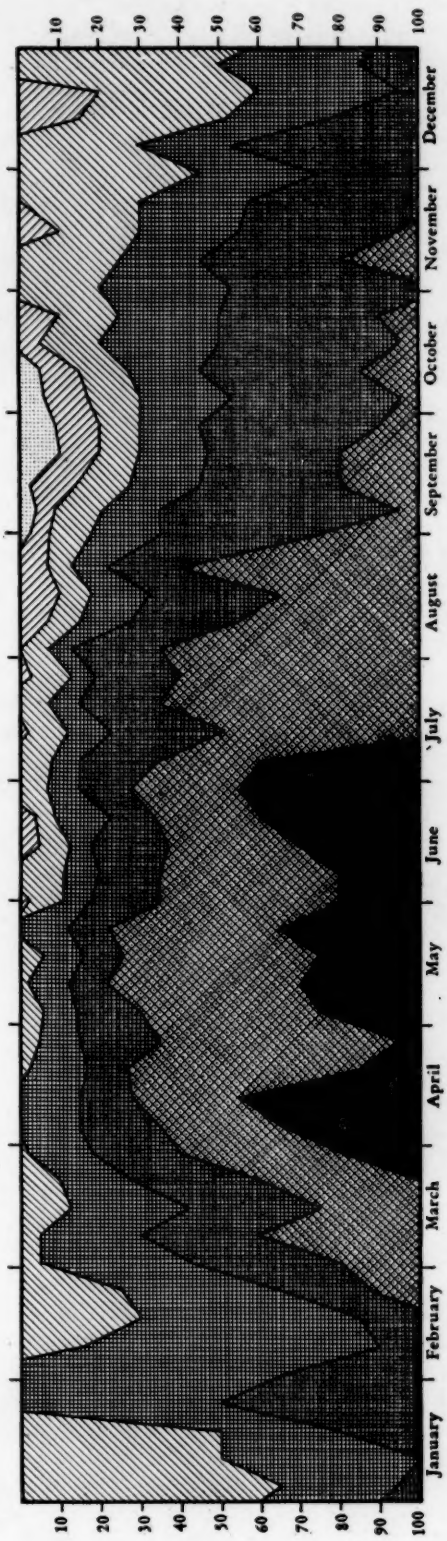

FIG. 7. Normal thermal rhythm in the upper 100 meters, in Monterey Bay, obtained by combining the thermal rhythms of 1929–1937, inclusive. For interpretation of symbols, see p. 357. For discussion, see p. 361.

given the following characterization: "First, the thermal gradient is decidedly more gentle than in other seasons. On the average, the temperature decreases less than two degrees from the surface to a depth of 90 meters. Second, the temperatures are quite high, considering the fact that we are concerned with the middle of the winter season. Between 30–40 meters and 90 meters, the temperature is normally 11°, and above this stratum it is 12°." The Upwelling Period is characterized by the rise above the 100 meter level of water of 9°–8°. The 8° water proved to have a double mode, but this was considered to be due to the scarcity of the material. The third, or Oceanic, period corresponds to an influx of comparatively warm water in the superficial strata. Its maximum occurs in September, but its volume varies considerably from year to year. "Water of 12° extends to a depth of about 30 m. and at the surface the temperature is normally not less than 15°," a very high temperature for this region, as the records show. This water is also of a deeper blue and of greater transparency than the normal coastal water of other seasons. However, it should be noted that relatively warm pulses of oceanic water may enter the bay on irregularly distributed occasions nearly throughout the entire year. Normally, these pulses are of short duration. The fall influx which Skogsberg (1936) named *the* Oceanic Period "occupies a special position" among these oceanic pulses "on account of its persistence from year to year and due to the fact that in most years it is of a fairly large size."

When we compare these results with those obtained during 1934–1937, we find that there are striking similarities between the conditions of the two periods of the Hydrobiological Survey. Thus the Upwelling Period recurred regularly in each of the years from 1929 to 1937, even though its intensity varied decidedly from year to year. Indeed, the variability in the size of this important phase in the hydrographic rhythm is evidently especially characteristic. It should be strongly emphasized, however, that despite these variations the shapes and extents of the 9° and 10° isotherms in figure 12 of Skogsberg (1936) and figure 7 of the present report are for all practical purposes nearly identical. The only notable exception from this general agreement is to be found in the early portion of the 10° isotherm, located in the Davidson Current section (see below). The duration of the 8° wave is the same in figures 12 and 7; and in figure 7 the gap between the two modes shows signs of filling up. It should be noted, however, that in figure 13 of Skogsberg (1936) the height of the 8° water wave is too great. The crest of this wave at station B should probably not reach even the 60 m. level (possibly to about 65 m.). The length of this pulse may also have been extended slightly too much in figure 13. The remaining two periods were perhaps somewhat less in agreement with the rhythm just outlined; but this should have been expected since both the Davidson Current and the warm water in the autumn are known by practical seafaring men to be of less constant nature. Thus, in 1937, the Davidson Current period was interrupted in the latter part of January by a rather pronounced, even though short, upwelling, in which even some 8° water was carried above the 100 m. level; and there were similar, although less extreme, waves in January of the three previous years. Furthermore, if we examine the Davidson Current period during 1929–1933, as represented by figures 7–11 of Skogsberg (1936), we shall find additional evidence of the inconstancy of this phase. The irregularities during 1934–1937, however, were so great that 11° water was carried up to the surface during the Davidson Current period as depicted in figure 7 of the present report contrary to figure 12 of Skogsberg (1936). The variations in the Oceanic Period in 1934–1937 were sufficiently large to eliminate the 15° water entirely from the surface and to bring wedges of 13° water to the surface in November and December (see figure 7 of the present report).

These differences should not cause us to lose sight of the striking fact that by and large the modifications of figure 12 of Skogsberg (1936) by the superimposition of the data from 1934–1937 are remarkably small. The basic rhythm remains. Of course, the question comes up whether the amount of data in the 1934–1937 period was large enough materially to modify a graph built on the very bulky material dating from 1929–1933. It has previously been noted that after the senior author ceased participating in the field trips, the number of observations was decidedly reduced. Thus, for instance, often observations were made only at every 10 m. level, instead of at every 5 m. level, as had previously been the rule. To this it should be remarked that in the calculations of the averages, etc., the 5 m. levels were filled in by interpolation which nearly always could be done without any

risk of distortion and which had the advantage of rendering the needed calculations easier. However, the period of 1934–1937 contained some prolonged intervals during which no observations were made and hence it has less statistical weight than it would have had, had all the four years been complete. The best proof that the small changes of figure 12 of Skogsberg (1936) are not caused by differences in the statistical weight of the material from 1929–1933 and of 1934–1937 is of course to be found in the close agreement of the individual years of 1934–1937 to the basic rhythm found during the previous years.

IV. COMPARISONS OF THE ANNUAL THERMAL CONDITIONS IN THE SUPERFICIAL STRATA

As in the previous report by Skogsberg (1936: 57), the thermal material has been dealt with from a number of different angles. The reasons for doing so are given on the page just cited. Also, as in the case of the material presented before, even though our present data were collected at a single station (B), the results can be considered as applicable to the larger portion of the bay because the thermal variations at different places within the bay have been demonstrated to deviate but little from those of the key station. Largely in accordance with Skogsberg (1936), the material will be treated from the following points of view. First, the thermal conditions at the surface, 50 m., and 100 m., presented by means of a graph giving the actual temperature readings (fig. 8) and by a graph giving the monthly averages (fig. 9), will be discussed. Next will be given the relative volumes of water of different degrees of temperature (figs. 10 and 11) for 1931–1937, the only years for which we have records from station B. As in 1936, an attempt will also be made to determine the deviations of the various monthly averages from the computed normal (fig. 12); this also covers the noted years. Finally (fig. 13), selected amplitudes of thermal variations will be discussed.

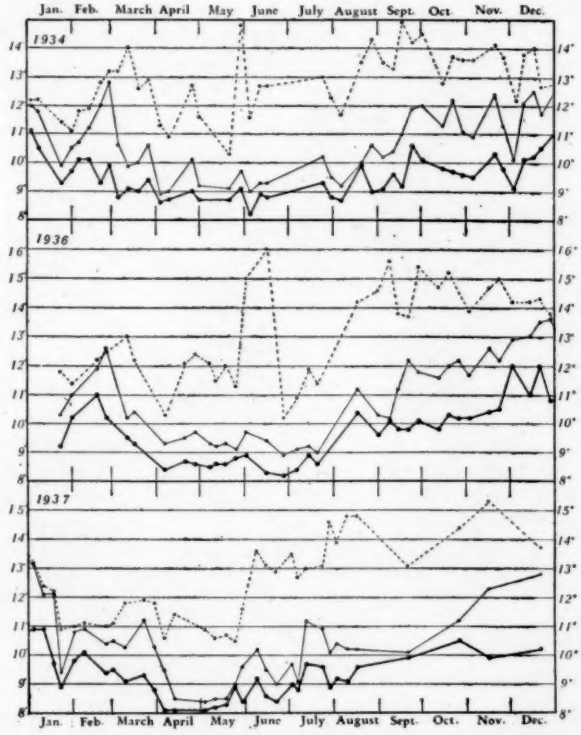
Jan. Feb. March April May June July August Sept. Oct. Nov. Dec.
1934
1936
1937
Jan. Feb. March April May June July August Sept. Oct. Nov. Dec.

FIG. 8. Temperatures at surface, 50, and 100 m., at station B, in 1934, 1936, and 1937. Surface temperatures shown by broken lines, those at 50 and 100 m. by continuous lines, of which the ones of the latter level are somewhat heavier. Individual temperature readings shown by dots.

THERMAL CONDITIONS AT THE SURFACE, 50 METERS, AND 100 METERS (FIGS. 8 AND 9)

The thermal records of 1934–1937 show a striking similarity to those of 1929–1933 if we take into consideration that the very high frequency of thermal oscillations characteristic of this region was hidden by the scarcity of observations. In order better to understand the effect of differences in frequency of sampling on the picture obtained of the thermal conditions in this region, see page 58 and compare figures 14 and 15 of Skogsberg (1936). As is noted on page 58, circulation in the Bay of Monterey is so intense that, even were observations made within the short interval of one hour, duplication of records would not be forthcoming, at least not as a rule.

The thermal development of the surface water was, just as in 1929–1933, quite different from year to year. Despite these yearly differences, there was evidence of a general trend throughout the year, a trend which agreed to a fair extent with the one established for 1929–1933. (Compare right bottom graph of figure 16 in Skogsberg, 1936, with right top graph of our figure 9.) From this general trend the individual years differed to varying extents. The most striking deviation from this trend may be said to have

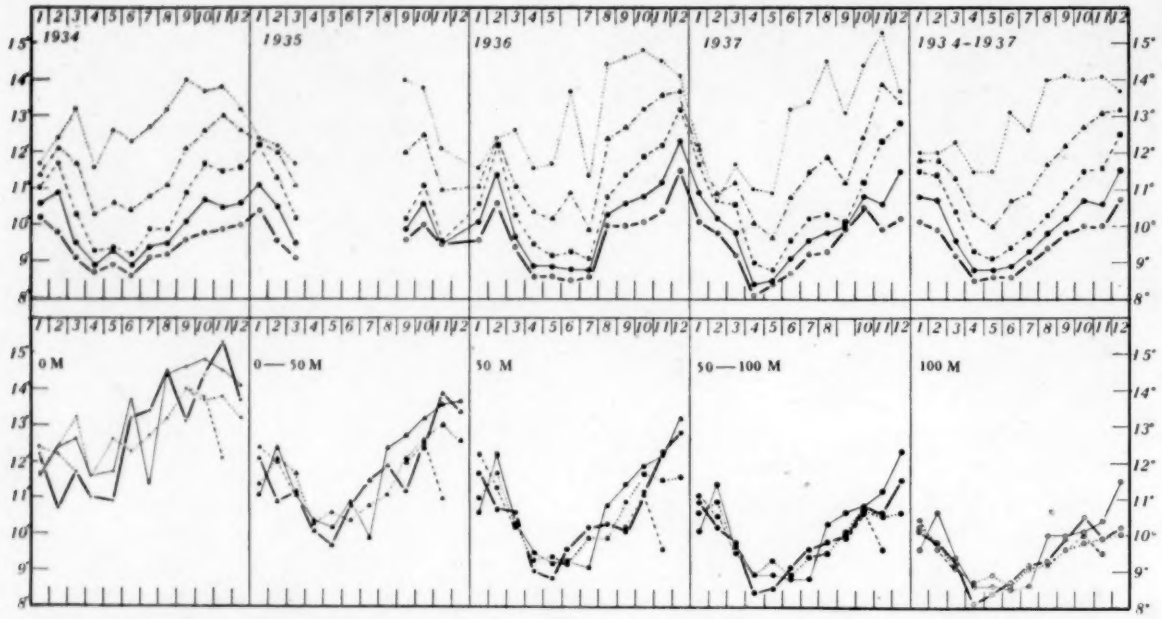

FIG. 9. Monthly average temperatures at surface, surface to 50 m., 50 m., 50 m. to 100 m., and 100 m., at station B, in 1934–1937. In graphs of upper row, dotted line and solid circles indicate surface; line with dots and dashes and triangles, indicates surface to 50 m.; broken line with squares, 50 m.; continuous, rather heavy line, with solid circles, 50 m. to 100 m.; and heavier continuous line with open circles, 100 m. In graphs of lower row, dotted line indicates the year 1934; line of dashes, 1935; fine, continuous line, 1936; and heavy, continuous line, 1937.

occurred in 1936 when in June, i. e., at the height of the upwelling season, the surface temperature suddenly soared to not less than 16.0°, only to drop even more suddenly to 10.2°. However, in no case did we find the pronounced irregularity of 1931, as expressed by figure 15 of Skogsberg (1936).

It may be observed in passing that this sudden drop in the temperature, from 16.0° to 10.2° is the most sudden observed during 1929–1937 and that it approaches the entire range of variation in surface temperature recorded in these nine years. Better than anything else, these sudden changes, together with the general irregularities, illustrate the unusual nature of our hydrography. This part of the coast does not have any what may be termed endemic water, i. e., water which lingers in this general neighborhood for a prolonged period. The water is constantly washed toward and away from the coast, as well as along the coast.

As in 1929–1933, there sometimes were found persistent trends over a fairly considerable period, indicating water movements on a large scale. For instance, in July, August, and September 1936, there was a nearly consistent upward trend in the temperatures of the superficial water, from 10.2°–15.6°, indicating a gradual approach of a large body of oceanic water.

Somewhat less pronounced irregularities characterized the temperatures at 50 meters, not only within the individual year but also the seasonal trend was more closely followed from year to year. On a few occasions, as in 1929–1933, the thermal changes were both sudden and strong. The independence of the temperature changes at 50 m. and at the surface was again obvious.

Mutatis mutandis, the same can be said of the water at the 100 m. level; its irregularities were even less than those at the 50 m. level. Moreover, as in 1929–1933, the curves at 100 m. and 50 m. showed a fairly pronounced parallelism, suggesting that the body of water between these two levels probably moved in most cases more or less as a unit. Only on a few occasions, as is well illustrated by our figure 8, were the thermal trends opposite at the 50 and 100 m. levels; and only very seldom were the thermal changes at 100 m. more pronounced than those at 50 m., as in December 1936.

This unity of movement between the 50 and 100 m. strata stands in sharp contrast to the independence in the movements of the uppermost layers, an independence that can be not only

deducted from the independence of the temperatures but also demonstrated by actual float experiments, as was done by Skogsberg (1936: 107 and fig. 33).

In regard to the monthly averages, it seems advisable to give the actual figures on which figure 9 is based, i. e., the averages for each of the months of 1934–1937, as well as the "normal" values for the whole period covered by this report; in other words, the averaged monthly averages for 1934–1937. These "normal" values are given in the next table. The months are indicated by Roman numerals.

1934–1937
STATION B

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Surf.	12.0°	12.0°	12.3°	11.5°	11.5°	13.1°	12.6°	14.0°	14.1°	14.0°	14.1°	13.7°
0–50 m.	11.8°	11.8°	11.3°	10.3°	10.0°	10.7°	10.9°	11.7°	12.2°	12.7°	13.1°	13.2°
50 m.	11.5°	11.4°	10.4°	9.3°	9.1°	9.4°	9.8°	10.3°	10.9°	11.5°	11.6°	12.5°
50–100 m.	10.8°	10.7°	9.6°	8.8°	8.8°	8.9°	9.3°	9.8°	10.2°	10.7°	10.7°	11.5°
100 m.	10.1°	9.9°	9.2°	8.5°	8.6°	8.6°	9.0°	9.4°	9.8°	10.0°	10.0°	10.7°

The "normal" yearly averages for 1934–1937 were as follows: surface, 12.9°; 0–50 m., 11.6°; 50 m., 10.6°; 50–100 m., 10.0°; and 100 m., 9.5°.

The corresponding averages for 1929–1933 are to be found on pages 61 and 62 of Skogsberg (1936). It should be noted that in regard to the "normal" annual averages, the differences never exceed 0.1°. It is true that in respect to the "normal" monthly averages the differences are larger, but even in this case the agreement vastly overshadows the differences.

In order to obtain the best possible "normal" monthly and annual values for this region, the thermal values from stations 4 and B of all the investigated years have been averaged. This procedure yielded the following results.

1929–1937
STATIONS 4 AND B

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Surf.	12.1°	12.0°	12.3°	11.7°	11.8°	13.1°	12.8°	13.8°	14.3°	13.9°	13.4°	13.3°
0–50 m.	11.9°	11.9°	11.2°	10.5°	10.4°	10.8°	10.9°	11.6°	12.2°	12.2°	12.2°	12.6°
50 m.	11.6°	11.4°	10.3°	9.2°	9.2°	9.4°	9.8°	10.2°	10.8°	11.3°	11.4°	12.3°
50–100 m.	11.0°	10.8°	9.6°	8.9°	8.9°	8.9°	9.2°	9.8°	10.1°	10.4°	10.3°	11.2°
100 m.	10.3°	10.0°	9.2°	8.6°	8.6°	8.6°	9.0°	9.4°	9.7°	9.9°	9.9°	10.6°

The "normal" annual averages for the period between 1929 to 1937, inclusive, were as follows: surface, 12.9°; 0–50 m., 11.5°; 50 m., 10.6°; 50–100 m., 9.9°; and 100 m., 9.5°. As will be seen from a comparison, these are values which are practically identical with those obtained from the period 1934–1937. In other words, they may be considered as really representative of this region.

It should also be noted that the similarities between the "normal" monthly values for the various levels of 1929–1937 and the corresponding values for 1929–1933 and 1934–1937 are so great that it has not been considered necessary to give a special graph to show the first ones. Especially the water from 50 m. to 100 m. has curves of remarkable similarities. Hence for the characterization of these curves, we simply refer to Skogsberg (1936: 62).

The thermal characteristics of the individual years included in figure 9 are shown in the following tables:

1934
STATION B

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Surf.	11.7°	12.4°	13.2°	11.6°	12.6°	12.3°	12.7°	13.2°	14.0°	13.7°	13.8°	13.2°
0–50 m.	11.4°	12.1°	11.7°	10.3°	10.6°	10.4°	10.8°	11.1°	12.1°	12.6°	13.0°	12.6°
50 m.	11.0°	11.7°	10.3°	9.3°	9.4°	9.2°	9.9°	9.9°	10.9°	11.7°	11.5°	11.6°
50-100 m.	10.6°	10.9°	9.5°	8.9°	9.3°	8.9°	9.4°	9.5°	10.1°	10.7°	10.5°	10.6°
100 m.	10.2°	9.8°	9.1°	8.7°	8.9°	8.6°	9.1°	9.2°	9.6°	9.8°	9.9°	10.0°

The annual averages, i. e., the averages of all the monthly averages, were: surface, 12.9°; 0–50 m., 11.6°; 50 m., 10.5°; 50–100 m., 9.9°; and 100 m., 9.4°.

1935
STATION B

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Surf.	12.4°	12.2°	11.7°						14.0°	13.8°	12.1°	
0–50 m.	12.4°	12.0°	11.1°						12.0°	12.5°	11.0°	
50 m.	12.2°	11.3°	10.2°						10.2°	11.1°	9.6°	
50–100 m.	11.1°	10.5°	9.5°						9.9°	10.6°	9.6°	
100 m.	10.4°	9.6°	9.1°						9.6°	10.0°	9.5°	

1936
STATION B

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Surf.	11.6°	12.4°	12.6°	11.6°	11.7°	13.7°	11.4°	14.4°	14.6°	14.8°	14.5°	14.1°
0–50 m.	11.1°	12.4°	11.1°	10.4°	10.2°	10.9°	9.9°	12.4°	12.7°	13.2°	13.6°	13.7°
50 m.	10.6°	12.2°	10.3°	9.5°	9.2°	9.3°	9.1°	10.8°	11.4°	11.9°	12.2°	13.2°
50–100 m.	10.1°	11.4°	9.7°	8.9°	8.9°	8.8°	8.8°	10.3°	10.6°	10.8°	11.2°	12.3°
100 m.	9.6°	10.6°	9.4°	8.6°	8.6°	8.5°	8.6°	10.0°	10.0°	10.1°	10.4°	11.5°

The following yearly values were found: surf., 13.1°; 0–50 m., 11.8°; 50 m., 10.8°; 50–100 m., 10.1°; and 100 m., 9.7°.

1937
STATION B

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Surf.	12.2°	10.7°	11.7°	11.0°	10.9°	13.2°	13.4°	14.5°	13.1°	14.4°	15.3°	13.7°
0–50 m.	12.1°	10.9°	11.2°	10.1°	9.7°	10.8°	11.5°	11.9°	11.2°	12.4°	13.9°	13.4°
50 m.	11.7°	10.7°	10.6°	9.0°	8.8°	9.6°	10.2°	10.3°	10.1°	11.2°	12.3°	12.8°
50–100 m.	10.9°	10.2°	9.8°	8.4°	8.5°	9.1°	9.6°	9.8°	10.0°	10.8°	10.6°	11.5°
100 m.	10.1°	9.8°	9.2°	8.1°	8.4°	8.7°	9.2°	9.3°	9.9°	10.5°	9.9°	10.2°

The annual averages were as follows: surface, 12.8°; 0–50 m., 11.6°; 50 m., 10.6°; 50–100 m., 9.9°; and 100 m., 9.4°.

As will be seen from the lower left graph of figure 9 and a comparison between this and the corresponding graph of Skogsberg (1936: fig. 16), the surface temperatures of this region are very variable from one year to the next. The same high degree of variability is also evident from figure 23 of Skogsberg (1936) representing the monthly temperature averages at the shore near the Hopkins Marine Station from 1919 to 1934. Indeed, it may hardly be justifiable to talk of a "normal" surface temperature curve for this region. Careful examination will show that practically the only characteristic that stands forth is that on the average the highest surface temperature is reached in September; and even this rule has many exceptions, the maximum shifting from April to November. There also seems, as a rule, to be a slight depression in April.

In respect to the remaining curves in the lower section of figure 9, hardly anything needs to be added to what was stated about the corresponding curves by Skogsberg (1936: 64, 65). Suffice it again to draw attention to the remarkable depression of these curves during the Upwelling Period and to the fact that by and large the differences among the various years become increasingly less the greater is the depth depicted by the curves. However, even in these curves sudden irregularities may occur, as for instance in November 1935 when, instead of rising, the temperature for 50–100 m. sank to 9.6° from 10.6°. And in 1936 the February curve showed both at 50 and 100 m. a sudden and unseasonal rise.

AMOUNTS OF WATER OF DIFFERENT DEGREES OF TEMPERATURE IN THE UPPER ONE HUNDRED METERS (FIGS. 10 AND 11)

For the sake of ready comparison of the thermal conditions of the various years, we decided to follow Skogsberg (1936: 65) and calculate the amounts of water of different degrees in each month of the years investigated and to present the results in both a tabular and a graphic form. Since the water investigated was 100 meters deep, the values obtained, of course, express both depth in meters and percentage of the stratum.

As was done in the first report by Skogsberg (1936), we shall first present what may be called the "normal" distribution of temperatures, based on the averages for the years 1931–1937.

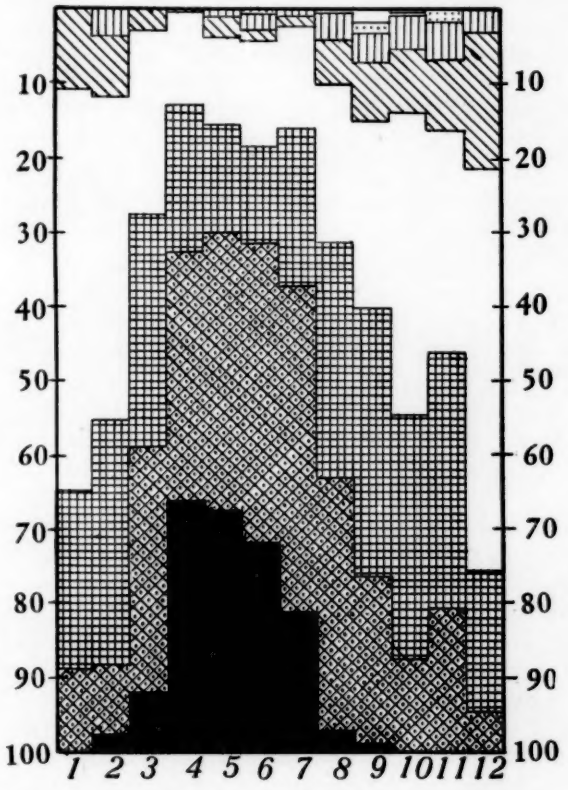

FIG. 10. Amounts of water of different degrees of temperature in the upper 100 m., at station B. "Normal" conditions, obtained by averaging data from 1931 to 1937. Black, 8°; oblique crosshatching, 9°; straight crosshatching, 10°; for the sake of clarity and emphasis, 11° and 12° have been left blank; 13°, oblique, parallel lines; 14°, vertical, parallel lines; 15°, dots; and 16°, blank. For the sake of simplicity, the symbols for the temperatures are placed in the positions in which the temperatures occurred in nature. Numerals below indicate the months.

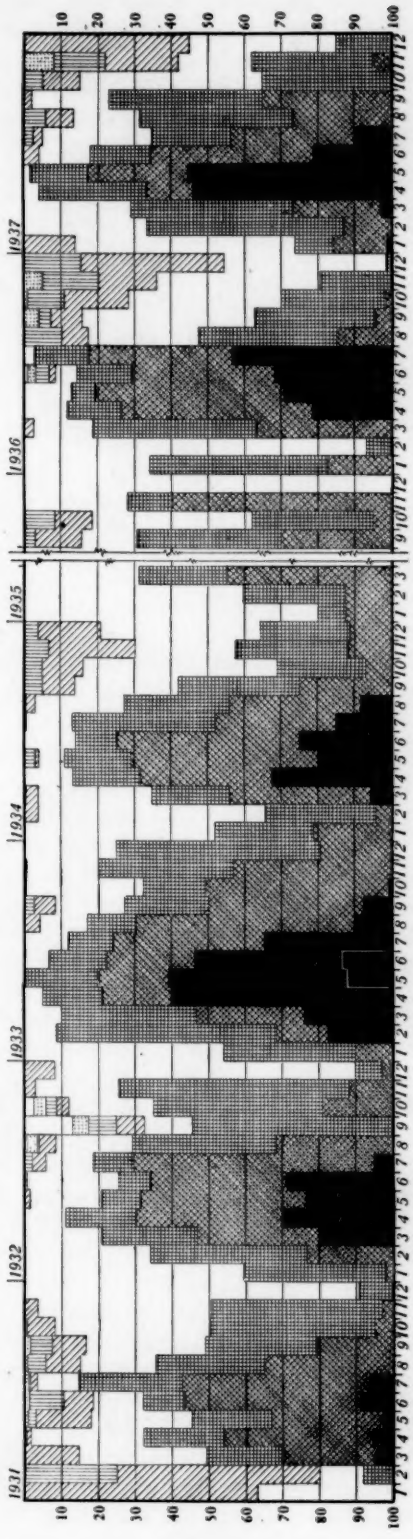

FIG. 11. Amounts of water of different degrees of temperature in the upper 100 m., at station B, for the individual years from 1931 to 1937. For explanation of symbols, see legend of fig. 10.

Graphically these values are given in our figure 10. Values of 0.0 refer to quantities of less than 0.1 per cent. Depths recorded in meters. It should be noted that in the calculation of the following monthly "normals" the investigated months of 1935 were included.

Temp.	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
16°						0.1		0.0	1.9	0.3		
15°					0.1	0.6	0.2	0.6	1.4	0.6	1.9	
14°		3.6	0.0	0.0	0.9	2.2	0.8	3.6	3.9	4.5	5.1	3.2
13°	11.0	8.4	3.0	0.2	2.9	2.4	1.4	6.0	7.8	8.5	9.4	18.2
12°	24.9	17.9	5.7	3.8	5.0	5.0	6.0	7.8	10.9	12.7	11.5	20.2
11°	28.8	25.3	19.0	8.8	6.4	8.2	7.4	13.3	14.3	28.3	18.6	34.0
10°	24.0	32.8	31.2	20.0	15.4	13.2	21.2	31.8	36.4	32.6	34.4	18.8
9°	11.1	9.5	33.1	33.2	37.5	40.3	43.9	33.9	22.4	12.5	19.2	5.3
8°	0.2	2.5	8.1	33.9	29.8	25.9	18.9	3.0	1.1	0.1		
7°					2.0	2.2						

The "normal" thermal indices (*cf.* Skogsberg, 1936: 66, 70, etc.) were derived from the above table by adding all the monthly depths or percentage of each degree of temperature. They were:

16°	15°	14°	13°	12°	11°	10°	9°	8°	7°
2.3	5.4	27.8	79.2	131.4	212.4	311.8	301.9	123.5	4.2

Indices for 7°–9° and 7°–10° were, respectively, 429.6 and 741.4; that for 14°–16° was 35.5.

From the above indices it will be clear that from 1931 to 1937 the "normal" situation in the upper 100 m. was as follows. The most common temperatures were 9°, 10°, and 11°; and among these 10° was the most common with an index of not less than 311.8. Temperatures below 8° were very rare; so were also temperatures above 13.9°, although to a less striking extent. As in 1929–1933, the curve representing the combined temperatures of 7°–10° formed a nearly typical probability curve. This curve had, however, as before, a skewness, its mode being displaced to the period of April–May. This part of the hydrographic picture was, of course, entirely dominated by the upwelling phenomenon. In December–February the Davidson Current was not strong enough to prevent water of 9° from being present above the 100 m. level. In respect to the superficial layers, the picture of 1931–1937 was quite similar to the one representing the "normal" for the 1929–1933 period (Skogsberg, 1936: fig. 17). During the Davidson Current months water of 13° and 14° occupied a fairly thick layer on the average despite the noted variability of this hydrographic phase. In spring and early summer the upwelling water forced out the warm superficial water. On the other hand, the late summer and the autumn months were characterized by warm water becoming increasingly thick. This, as we know, is a phenomenon associated with the inflow into the bay of transparent, truly oceanic water.

The conditions within the individual years, from 1931 to 1937, inclusive, are presented in figure 11 and in table 2 of the appendix. Before the tables are studied, it should be noted that the values for 1931–1933 are different from those given on page 69 of Skogsberg (1936). The differences, of course, are due to the fact that the results given in the report of 1936 were based exclusively on the upper 50 meters while the following ones were derived from an analysis of the upper 100 meters.

The following table gives the thermal indices for 1931–1937, except for 1935, in which year observations were not taken for several months. As before, the data come from station B and cover the upper 100 meters.

Temp.	1931	1932	1933	1934	1936	1937
16°		15.8			0.7	
15°	5.0	10.6			12.0	8.0
14°	48.6	12.8	2.7	23.9	57.7	27.1
13°	189.0	31.9	10.7	71.4	92.6	105.0
12°	173.0	94.6	33.5	159.5	169.9	111.3
11°	226.1	250.3	171.2	208.9	213.8	209.3
10°	272.7	367.0	343.0	305.7	271.3	358.8
9°	257.4	310.5	370.5	324.1	256.1	236.6
8°	27.9	106.5	243.1	106.3	125.9	143.7
7°			25.3			
7°–9°	285.3	417.0	638.9	430.4	382.0	380.3
7°–10°	558.0	784.0	981.9	736.1	653.3	739.1

As in the case of the report of 1936, it is of course necessary for the reader to reach an understanding of most of the information given above from a direct study of the tables and graphs. Only a few features can be stressed in the following remarks.

Even a rather cursory inspection of figure 11 will suffice to demonstrate that its most outstanding features are the regular recurrence of the black histograms representing the (7°–) 8° water, the changes in the sizes of these histograms, and the comparatively uniform shapes of the histograms of the 9° water as placed above the (7°–) 8° water. As in the case of figure 10, the (7°–) 8°–9° water has, broadly speaking, the symmetry of typical probability curves. The black histograms of the (7°–) 8° water vary not only in size but also to some extent in shape. Some of them are quite asymmetrical; however,

the deviations from this pattern evidently are to some extent associated with the variations in size. As far as size is concerned, the index of the 8° water of 1931 is by far the smallest, while that of 1933 represents the maximum. The same was true in the report of 1936, the years 1934–1937 having 8° water of intermediate volume. The difference between the (7°–) 8° water in 1931 and 1933 is expressed by the indices which are, respectively, 27.9 and 268.4; i. e., the 1933 value is nearly ten (9.6) times the greater. If we take the whole body of cold water, (7°–) 8°–10°, into account, we get the same result, viz., 1931 was the warmest and 1933 the coldest among the years examined, even though the difference is less striking, probably because of the fact that some of the cold water, i. e., the 10° water, had at least in some cases a superficial rather than a deep origin (see Skogsberg, 1936: 70). The total index for water of (7°–) 8°–10° was in 1931, 558.0 while in 1933, it was not less than 981.9, the latter thus being less than twice the former. When the various years are compared from the point of view of the thermal indices of the superficial strata, we obtain the following results if we define warm water as ranging in temperature between 14° and 16°.

1931	1932	1933	1934	1936	1937
53.6	39.2	2.7	23.9	70.4	35.1

That is to say that the indices for 1937 and 1932 were the ones closest to "normal" condition, i. e., 35.5 (p. 368), in the order given. The year 1933, just as in the case of the deep water, was the coldest, with a yearly index of only 2.7: and 1936 was the warmest with an index of 70.4, hence about twice the "normal" value. It may finally be worth noting that even though 1931 was not the warmest year as far as the indices show, nevertheless comparatively warm water (13°) penetrated more deeply in this than in any other year, viz., to a monthly average depth of about 80 m.

The phenomenon of deviations from the thermal "normality" was treated in still another manner because of its significance. The calculations and construction were carried out in the same manner as in Skogsberg (1936: 72) except that the deviations were not calculated in percentages of the total ranges but were given only

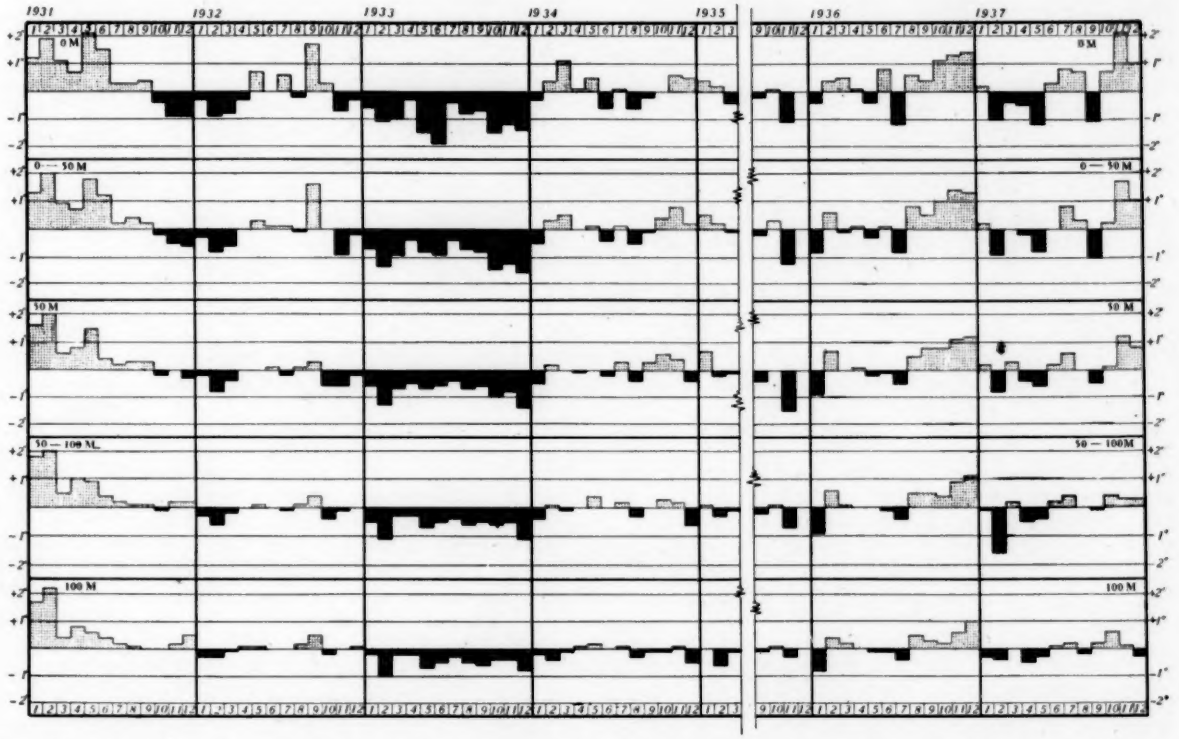

FIG. 12. Deviations from "normal" thermal conditions at station B, from 1931 to 1937. In this figure (as is in fig. 19 of Skogsberg, 1936), monthly deviations above "normal" are shown in dotted surfaces while minus deviations are shown in black. Months indicated by short lines along top and base of graph.

in actual degrees of temperature. The results of this operation are to be found in figure 12 and in the tables on which this composite graph is based.

The most outstanding features of figure 12 are, first, that the deviations are mostly distributed without any evident regularity, the + and − deviations alternating with each other in an apparently random manner. Only on one occasion did the deviations consistently have the same sign for more than one year, i. e., in the 1933 cold period when not less than sixteen consecutive subnormal months were recorded. Otherwise nine consecutive months represented the longest run of the same sign, i. e., in 1931. Second, the deviations in the superficial and deep waters usually had the same sign. Third, the deviations were as a rule rather slight, deviations of more than two degrees occurring only on a few occasions. The last should be viewed against the fact that the total range of variation was very slight; see below p. 372.

Surface	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
1931	1.2	1.9	1.1	0.7	2.1	1.5	0.3	0.3	0.4	−0.4	−0.9	−0.9
1932	−0.3	−0.9	−0.8	−0.3	0.7	0.0	0.6	−0.2	1.7	0.3	−0.7	−0.3
1933	−0.6	−1.1	−1.0	−0.3	−1.5	−1.9	−0.4	−0.8	−0.7	−1.5	−1.2	−1.4
1934	−0.3	0.4	1.1	0.1	0.5	−0.6	0.1	−0.6	−0.2	0.0	0.6	0.5
1935	0.4	0.2	−0.4						−0.2	0.1	−1.1	
1936	−0.4	0.4	0.5	0.1	−0.4	0.8	−1.2	0.6	0.4	1.1	1.3	1.4
1937	0.2	−1.0	−0.4	−0.5	−1.2	0.3	0.8	0.7	−1.1	0.7	2.1	1.0
Surf., 50 m.												
1931	1.3	2.0	0.9	0.7	1.8	1.2	0.2	0.4	0.2	−0.2	−0.5	−0.6
1932	−0.3	−0.8	−0.6	0.0	0.3	0.1	0.1	−0.1	1.6	0.0	−0.9	−0.2
1933	−0.7	−1.3	−0.9	−0.4	−0.8	−0.9	−0.4	−0.7	−0.8	−1.4	−1.2	−1.5
1934	−0.5	0.3	0.5	0.0	0.1	−0.4	0.1	−0.5	−0.1	0.4	0.8	0.2
1935	0.5	0.2	−0.1						−0.2	0.3	−1.2	
1936	−0.8	0.6	−0.1	0.1	−0.3	0.1	−0.8	0.8	0.5	1.0	1.4	1.3
1937	0.2	−0.9	0.0	−0.2	−0.8	0.0	0.8	0.3	−1.0	0.2	1.7	1.0
50 m.												
1931	1.6	2.0	0.6	0.8	1.5	0.4	0.2	0.3	0.3	−0.2	0.0	−0.3
1932	−0.2	−0.8	−0.4	0.0	0.0	0.1	−0.2	0.1	0.3	−0.6	−0.6	−0.2
1933	−0.6	−1.3	−0.7	−0.5	−0.7	−0.6	−0.4	−0.7	−0.6	−1.0	−0.8	−1.4
1934	−0.5	0.2	0.0	−0.1	0.0	−0.2	0.3	−0.4	0.3	0.6	0.4	−0.4
1935	0.7	−0.2	−0.1						−0.4	0.0	−1.5	
1936	−0.9	0.7	0.0	0.1	−0.2	−0.1	−0.5	0.5	0.8	0.8	1.1	1.2
1937	0.2	−0.8	0.3	−0.4	−0.6	0.2	0.6	0.0	−0.5	0.1	1.2	0.8
50–100 m.												
1931	1.8	2.0	0.5	1.0	0.9	0.4	0.2	0.1	0.1	−0.1	0.2	0.2
1932	−0.3	−0.6	−0.2	0.0	0.1	0.0	−0.1	0.1	0.4	−0.4	−0.1	0.0
1933	−0.5	−1.1	−0.3	−0.3	−0.7	−0.5	−0.4	−0.6	−0.5	−0.6	−0.5	−1.1
1934	−0.4	0.1	−0.1	0.0	0.4	0.0	0.2	−0.3	0.0	0.3	0.2	−0.6
1935	0.1	−0.3	−0.1						−0.2	0.1	−0.7	
1936	−0.9	0.6	0.1	0.0	0.0	−0.1	−0.4	0.5	0.5	0.4	0.9	1.1
1937	−0.1	−1.6	0.2	−0.5	−0.4	0.2	0.4	0.0	−0.1	0.4	0.3	0.3
100 m.												
1931	1.7	2.2	0.4	0.8	0.6	0.4	0.2	0.1	0.0	0.0	0.2	0.5
1932	−0.3	−0.3	−0.1	0.1	0.1	0.0	0.0	0.2	0.5	−0.2	0.0	0.1
1933	−0.2	−1.0	−0.2	−0.2	−0.7	−0.5	−0.3	−0.5	−0.6	−0.4	−0.4	−0.8
1934	−0.2	−0.4	−0.1	0.1	0.2	0.0	0.1	−0.3	−0.1	−0.1	0.1	−0.5
1935	0.0	−0.6	−0.1						−0.1	0.1	−0.3	
1936	−0.8	0.4	0.2	0.0	−0.1	−0.1	−0.4	0.5	0.3	0.2	0.6	1.0
1937	−0.3	−0.4	0.0	−0.5	−0.3	0.1	0.2	−0.2	0.2	0.6	0.1	−0.3

The same lack of regularity which we have found in regard to the monthly deviations, we also find if we compare the yearly averages for the nine years investigated. Restricting ourselves to the surface temperatures, we obtain the following results, showing not only this lack of regularity but also the very slight degree of deviation from one year to another.

1929	1930	1931	1932	1933	1934	1936	1937
13.0°	13.5°	13.3°	12.7°	11.7°	12.9°	13.1°	12.8°

MONTHLY AMPLITUDES OF THERMAL VARIATION

By and large the amplitudes of thermal variation showed the same unusual features in 1934–1937 as they did in the previous years covered by the 1936 report.

The results of our analysis of this aspect of the hydrography are presented in our figures 13 and 14 which are based on the tables of this section. In figure 13 all the years in which station B was examined are given for the sake of clarity. In the top row of histograms the surface conditions are given. In the series just below the conditions of the average temperatures of the entire body of water between 0 and 50 m. are given; in the one below this conditions at 50 m., etc. The total and average ranges are repeated each year for the sake of clarity of comparison, the former in broken lines, the average in heavy continuous lines. The ranges for the individual years are shown by thin, continuous lines and stippled areas. In the table given below, the total monthly ranges are given (broken lines in figure); in table 3 of the appendix the ranges of the individual months as well as the averages of the monthly ranges for 1931–1937 (heavy, continuous lines in figure) are presented. Months indicated by Roman numerals.

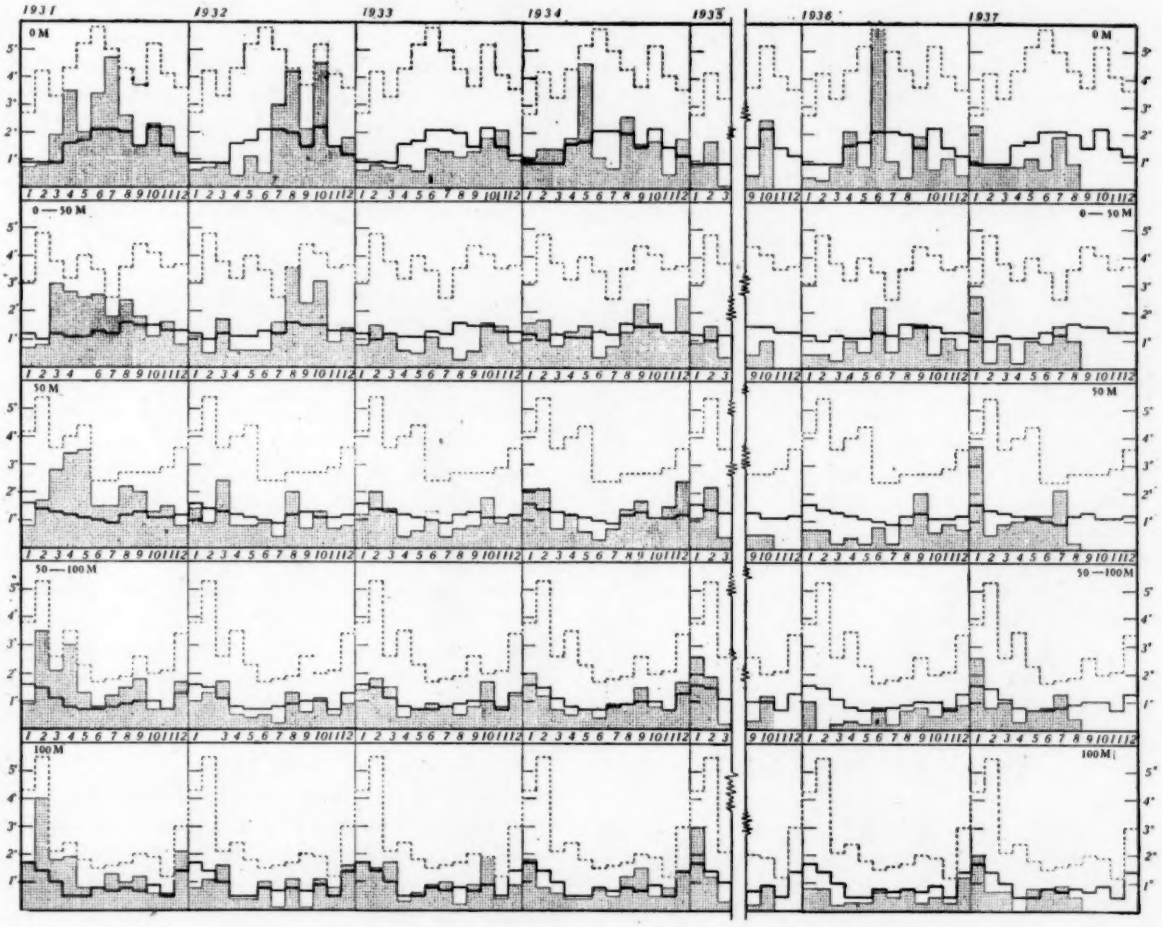

FIG. 13. Amplitudes of thermal variation, at station B, from 1931–1937. For further explanation, see the beginning of section C of chapter VI in Skogsberg (1936).

TOTAL MONTHLY AMPLITUDES OF THERMAL VARIATION
1931–1937

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Surface.....	13.6°	14.4°	14.0°	14.6°	15.4°	16.0°	15.9°	16.0°	16.7°	16.4°	15.0°	14.3°
	10.9°	10.2°	10.7°	10.3°	10.2°	10.2°	10.9°	11.7°	13.0°	11.2°	10.9°	10.7°
	2.7°	4.2°	3.3°	4.3°	5.2°	5.8°	5.0°	4.3°	3.7°	5.2°	4.1°	3.6°
0–50 m.....	13.6°	14.3°	13.3°	12.9°	13.3°	12.9°	12.1°	13.6°	15.2°	14.1°	14.0°	14.1°
	10.5°	9.5°	9.5°	9.7°	9.3°	9.4°	9.6°	10.0°	10.8°	10.0°	10.4°	10.4°
	3.1°	4.8°	3.8°	3.2°	4.0°	3.5°	2.5°	3.6°	4.4°	4.1°	3.6°	3.7°
50 m.....	13.6°	14.2°	12.2°	12.5°	12.8°	10.7°	11.2°	11.9°	12.3°	12.2°	12.6°	13.6°
	9.4°	8.8°	8.6°	8.5°	8.4°	8.3°	8.8°	9.2°	9.6°	9.5°	9.7°	10.0°
	4.2°	5.4°	3.6°	4.0°	4.4°	2.4°	2.4°	2.7°	2.7°	2.7°	2.9°	3.6°
50–100 m.....	13.4°	14.0°	11.0°	11.8°	10.3°	9.7°	10.2°	10.9°	11.7°	11.3°	11.6°	12.8°
	9.6°	8.7°	8.4°	8.3°	8.0°	8.0°	8.4°	9.0°	9.1°	9.3°	9.5°	9.4°
	3.8°	5.3°	2.6°	3.5°	2.3°	1.7°	1.8°	1.9°	2.6°	2.0°	2.1°	3.4°
100 m.....	13.2°	14.0°	10.3°	10.5°	9.6°	9.3°	9.7°	10.4°	10.6°	10.8°	10.5°	12.1°
	8.9°	8.5°	8.2°	8.1°	7.8°	7.8°	8.1°	8.7°	8.6°	8.9°	9.3°	9.1°
	4.3°	5.5°	2.1°	2.4°	1.8°	1.5°	1.6°	1.7°	2.0°	1.9°	1.2°	3.0°

From the above table it will also be evident that the total amplitude of thermal variation at the surface, regardless of the month, was 6.5°, from 16.7°, occurring in September, to 10.2°, found in February, May, and June.[1] Considering the fact that station B is located in the temperate zone and that not less than seven years were investigated, 6.5° must be considered a very narrow amplitude.

The value of 6.8° given as the maximum amplitude of thermal variation in the superficial stratum is in all probability close to the real maximum despite its smallness. On the other hand, the extreme narrowness of the monthly variability in figure 13 and associated tables is unquestionably in most instances to a considerable degree due to the scarcity of observations. A partial proof of the validity of this statement can be found in a comparison between the monthly ranges in 1931–1933 on the one hand and those of 1934–1937 on the other. As will be seen from such a comparison, the variations during the latter period were in general recorded to have been smaller than during the former period. This is in accordance with the number of observations. At the same time it should be noted that the differences were usually not very large and that in many cases the amplitudes during the 1934–1937 period were larger despite the smaller number of observations.

The maximum recorded monthly variation at the surface was 5.8°, a value found in June. It is of interest to note that the same value and month were found by Skogsberg (1936), although this complete agreement undoubtedly is nothing more than a coincidence.

An annual rhythm in the five year averages for the surface temperatures was reported by Skogsberg (1936). The rhythm was apparently present both in the curve showing total amplitudes (broken line) and in the one representing the monthly averages (continuous, heavy line). A somewhat similar apparent rhythm came forth in the corresponding curves for the period of 1931–1937. However, despite this, it probably should be said that such a rhythm is absent (or, at least, nearly so), considering the large number of erratic exceptions, so clearly brought forth by our figure 13.

In regard to the remaining depths, it may be said in brief that variation decreased in general with depth. If there is any annual rhythm in the sub-surface layers, it was found at the 100 m. level, where we found a variability of a pattern reverse to the rhythm indicated in the surface layer, i. e., variation was higher in winter than in summer. The total monthly maximum range

[1] All these values refer to station B. At station C, only three miles from B (see map on page 6 of Skogsberg, 1936), 9.9° was recorded on June 27, 1936. On June of that year the surface temperature was 16.7°, thus 6.8° higher. This is the maximum differential observed at station C. In other words, the maximum amplitude for the nine year period occurred within less than two weeks.

at 100 m. was but slightly smaller than the corresponding value for the surface, viz., 5.5° in February, as compared with 5.8° in June.

When we compared the variability at the surface with that at 50 m. and 100 m., we obtained the following results on the basis of the monthly averages for 1934–1937 at station B (fig. 14).

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Surf.	1.2°	1.1°	0.8°	1.6°	2.1°	2.5°	1.2°	1.3°	1.3°	1.6°	0.8°	1.2°
50 m.	1.9°	1.4°	0.6°	0.9°	0.7°	0.8°	1.0°	0.8°	1.4°	0.7°	1.2°	1.6°
Diff.	−0.7°	−0.3°	0.2°	0.7°	1.4°	1.7°	0.2°	0.5°	−0.1°	0.9°	−0.4°	−0.4°
100 m.	1.9°	0.9°	0.5°	0.3°	0.5°	0.7°	0.5°	0.8°	0.7°	0.6°	0.6°	1.3°
Diff.	−0.7°	0.2°	0.3°	1.3°	1.6°	1.8°	0.7°	0.5°	0.6°	1.0°	0.2°	−0.1°

We have given only the above averages and not the variations from one year to the next because the latter type of variation for the period of 1929–1933 was given by Skogsberg (1936: 78) and the values for 1934–1937 were of the same general pattern.

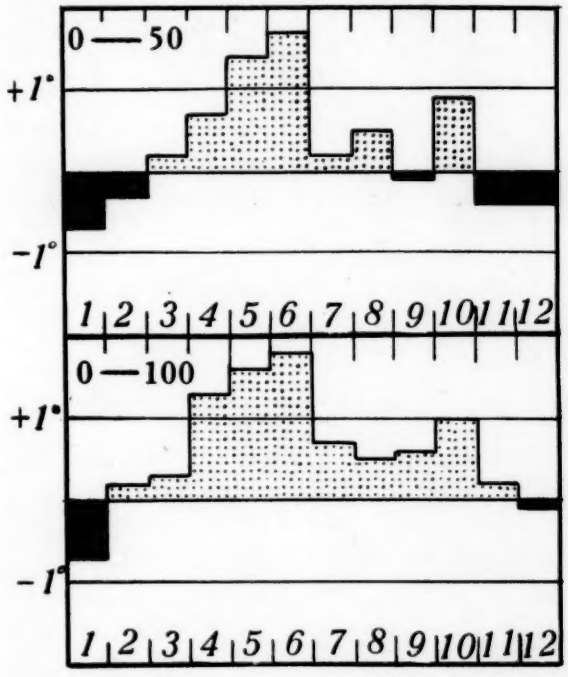

FIG. 14. Differences in the amplitudes of the monthly thermal variation between the surface and 50 m. and between the surface and 100 m. Minus deviations, shown in black, indicate that the amplitudes at 50 and 100 m. were greater than those at the surface. Plus deviations shown in stippling. Station B.

V. THERMAL CONDITIONS BELOW ONE HUNDRED METERS

The number of observations from below 100 m. reported by Skogsberg (1936) from station C was comparatively small, being restricted to two years, 1932 and 1933. Concerning this material, Skogsberg wrote on page 82 as follows: ". . . in spite of its limitation, the present material is likely to be quite representative on account of the circumstance that the variability of the lower strata unquestionably is much less than that of the upper 100 meters, and this . . . is remarkably narrow." This statement was amply supported by the results obtained at station C during 1934 to 1937, inclusive. On this account and considering the absence of hydrodynamic data, the treatment of this material will be very brief and summary.

The basic facts concerning the strata between 100 m. and 250 m. are presented in the following tables as well as in figures 15 and 16.

As can be easily calculated from the values presented in these tables and from those given on pages 83–85 of Skogsberg (1936), the average monthly temperatures at each depth and for each month did not vary more than 0.9° in the period from 1932 to 1937. In order to clarify this statement an example may be given. For the month of January of these years, at the depth of 150 m., the range of the monthly average temperatures was from 8.9° to 9.6°, or 0.7°. This was not an unusually low value which can be seen from the fact that the average monthly range of these monthly averages was even less than 0.5°. The pronounced stability of the temperatures from year to year was about the

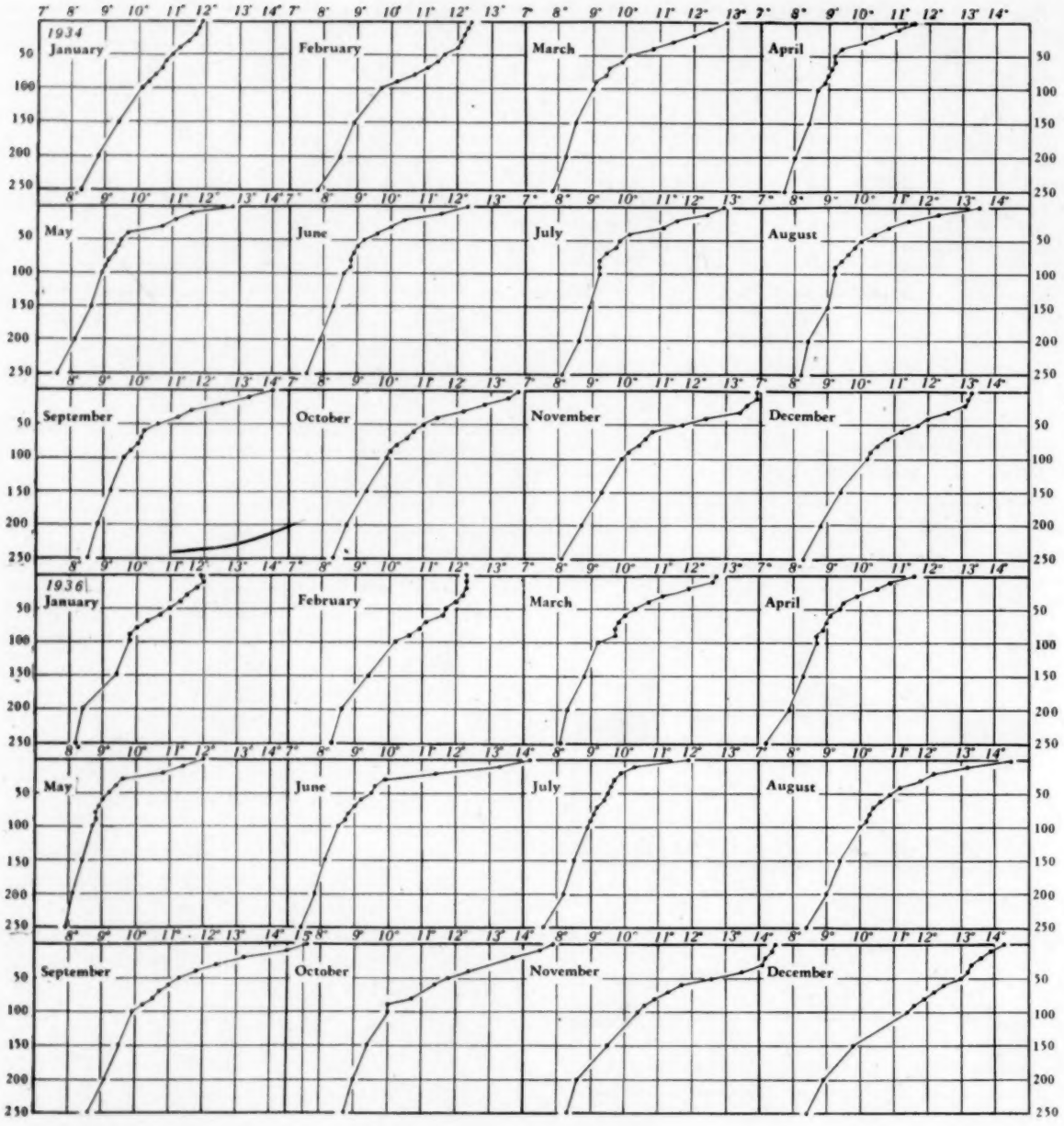

FIG. 15. Monthly average thermal gradients in the upper 250 m. at station C, during 1934 and 1936.

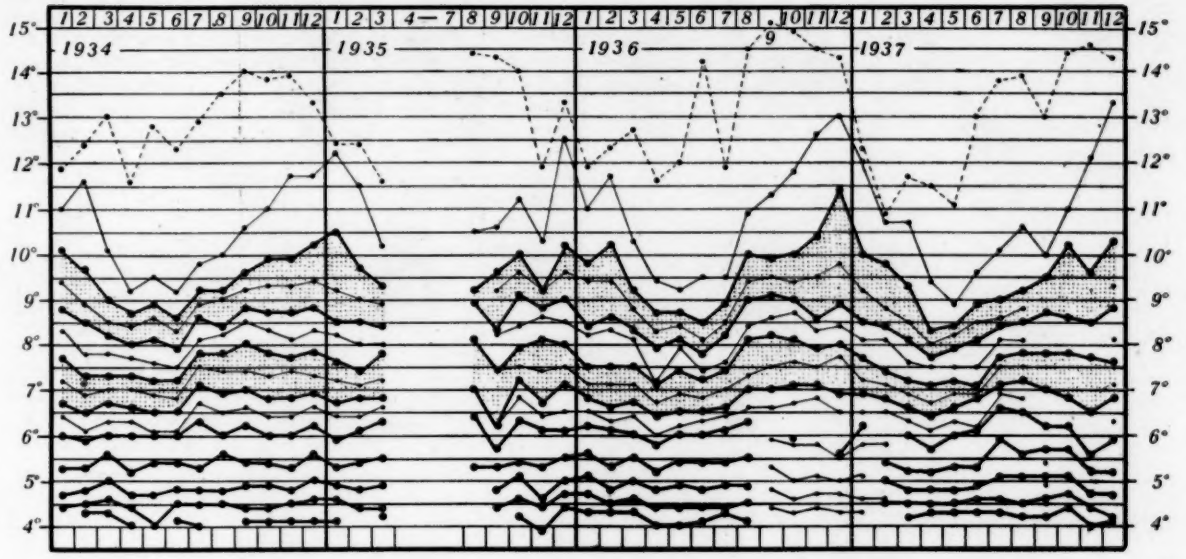

FIG. 16. Thermal monthly averages, at station C, between the surface and 900 m., during 1934–1937, inclusive. Surface readings connected by broken line; the 50, 150, 250, 350, and 450 m. levels indicated by lines somewhat lighter than the lines indicating 100, 200, 300, . . ., and 900 m. levels. In the last four months of 1936 and the first months of 1937, the 550, 650, 750, and 850 m. levels are also indicated by thin lines. In order to facilitate the tracing of the fluctuations, the spaces between 100 and 200 m., as well as that between 300 and 400 m., were stippled.

JANUARY

Range	100 m.	150 m.	200 m.	250 m.
1934	2.1°(11.3°–9.2°)	0.9°(9.9°–9.0°)	0.6°(9.1°–8.5°)	0.8°(8.8°–8.0°)
1935	3.0°(12.6°–9.6°)	1.0°(9.6°–8.6°)	0.8°(8.9°–8.1°)	0.7°(8.5–7.8°)
1936	— (9.8°)	— (9.4°)	0.5°(8.6°–8.1°)	— (8.2°)
1937	1.9°(10.9°–9.0°)	1.0°(9.6°–8.6°)	0.6°(8.8°–8.2°)	0.5°(8.3°–7.8°)
Average				
1934	10.1°	9.4°	8.8°	8.3°
1935	10.5°	9.2°	8.5°	8.2°
1936	9.8°	9.4°	8.4°	8.2°
1937	10.0°	9.2°	8.5°	8.1°
Average Gradient.				100–250 m.
1934				1.8°(10.1°–8.3°)
1935				2.3°(10.5°–8.2°)
1936				1.6°(9.8°–8.2°)
1937				1.9°(10.0°–8.1°)

FEBRUARY

Range	100 m.	150 m.	200 m.	250 m.
1934	0.5°(10.0°–9.5°)	0.7°(9.4°–8.7°)	0.9°(9.0°–8.1°)	0.8°(8.3°–7.5°)
1935	1.3°(10.3°–9.0°)	0.7°(9.2°–8.5°)	0.7°(8.8°–8.1°)	0.7°(8.3°–7.6°)
1936	1.3°(11.0°–9.7°)	0.1°(9.4°–9.3°)	0.5°(8.9°–8.4°)	0.6°(8.6°–8.0°)
1937	1.3°(10.5°–9.2°)	0.6°(9.1°–8.5°)	0.2°(8.5°–8.3°)	— (8.1°)
Average				
1934	9.7°	8.9°	8.5°	7.8°
1935	9.7°	9.0°	8.5°	8.0°
1936	10.2°	9.4°	8.6°	8.3°
1937	9.3°	8.5°	8.1°	7.6°
Average Gradient.				100–250 m.
1934				1.9°(9.7°–7.8°)
1935				1.7°(9.7°–8.0°)
1936				1.9°(10.2°–8.3°)
1937				1.7°(9.3°–7.6°)

MARCH

Range	100 m.	150 m.	200 m.	250 m.
1934	0.2°(9.0°–8.8°)	0.4°(8.7–8.3°)	0.3°(8.4°–8.1°)	0.5°(8.1°–7.6°)
1935	0.6°(9.6°–9.0°)	— (8.9°)	0.2°(8.5°–8.3°)	0.4°(8.2°–7.8°)
1936	0.6°(9.5°–8.9°)	— (8.8°)	— (8.3°)	— (8.1°)
1937	1.1°(9.9°–8.8°)	0.7°(8.8°–8.1°)	0.6°(8.3°–7.7°)	0.4°(7.8°–7.4°)
Average				
1934	9.0°	8.5°	8.2°	7.8°
1935	9.3°	8.9°	8.4°	8.0°
1936	9.2°	8.8°	8.3°	8.1°
1937	9.3°	8.5°	8.1°	7.6°
Average Gradient.				100–250 m.
1934				1.2°(9.0°–7.8°)
1935				1.3°(9.3°–8.0°)
1936				1.1°(9.2°–8.1°)
1937				1.7°(9.3°–7.6°)

APRIL

Range	100 m.	150 m.	200 m.	250 m.
1934	0.7°(9.1°–8.4°)	0.7°(8.8°–8.1°)	0.8°(8.5°–7.7°)	0.8°(8.1°–7.3°)
1936	0.4°(8.9°–8.5°)	0.2°(8.4°–8.2°)	0.9°(8.4°–7.5°)	0.5°(7.4°–6.9°)
1937	0.2°(8.4°–8.2°)	0.2°(8.1°–7.9°)	0.2°(7.8°–7.6°)	0.2°(7.6°–7.4°)
Average				
1934	8.7°	8.4°	8.0°	7.7°
1936	8.7°	8.3°	7.9°	7.2°
1937	8.3°	8.0°	7.7°	7.5°
Average Gradient.				100–250 m.
1934				1.0°(8.7°–7.7°)
1936				1.5°(8.7°–7.2°)
1937				0.8°(8.3°–7.5°)

MAY

Range	100 m.	150 m.	200 m.	250 m.
1934	0.3°(9.0°–8.7°)	0.3°(8.7°–8.4°)	0.3°(8.3°–8.0°)	0.2°(7.7°–7.5°)
1936	0.4°(8.9°–8.5°)	0.3°(8.5°–8.2°)	0.2°(8.2°–8.0°)	0.7°(8.1°–7.4°)
1937	0.4°(8.7°–8.3°)	0.5°(8.4°–7.9°)	0.6°(8.2°–7.6°)	0.6°(8.0°–7.4°)
Average				
1934	8.9°	8.6°	8.1°	7.6°
1936	8.7°	8.4°	8.1°	7.9°
1937	8.4°	8.2°	7.9°	7.5°
Average Gradient				100–250 m.
1934				1.3°(8.9°–7.6°)
1936				0.8°(8.7°–7.9°)
1937				0.9°(8.4°–7.5°)

JUNE

Range	100 m.	150 m.	200 m.	250 m.
1934	0.4°(8.8°–8.4°)	0.3°(8.4°–8.1°)	0.6°(8.2°–7.6°)	0.3°(7.6°–7.3°)
1936	0.6°(8.9°–8.3°)	0.8°(8.4°–7.6°)	0.6°(8.1°–7.5°)	0.5°(7.7°–7.2°)
1937	0.4°(9.1°–8.7°)	0.7°(8.9°–8.2°)	0.1°(8.1°–8.0°)	— (7.5°)
Average				
1934	8.6°	8.3°	7.9°	7.5°
1936	8.5°	8.1°	7.8°	7.4°
1937	8.9°	8.5°	8.1°	7.5°
Average Gradient				100–250 m.
1934				1.1°(8.6°–7.5°)
1936				1.1°(8.5°–7.4°)
1937				1.4°(8.9°–7.5°)

JULY

Range	100 m.	150 m.	200 m.	250 m.
1934	0.6°(9.5°–8.9°)	0.1°(8.9°–8.8°)	0.2°(8.7°–8.5°)	0.1°(8.2°–8.1°)
1936	0.8°(9.4°–8.6°)	0.4°(8.7°–8.3°)	0.1°(8.3°–8.2°)	1.3°(8.2°–6.9°)
1937	0.8°(9.4°–8.6°)	0.5°(8.9°–8.4°)	0.5°(8.7°–8.2°)	0.6°(8.3°–7.7°)
Average				
1934	9.2°	8.9°	8.6°	8.1°
1936	8.9°	8.5°	8.2°	7.6°
1937	9.0°	8.6°	8.4°	8.1°
Average Gradient				100–250 m.
1934				1.1°(9.2°–8.1°)
1936				1.3°(8.9°–7.6°)
1937				0.9°(9.0°–8.1°)

AUGUST

Range	100 m.	150 m.	200 m.	250 m.
1934	0.6°(9.5°–8.9°)	0.5°(9.2°–8.7°)	0.7°(8.8°–8.1°)	0.4°(8.4°–8.0°)
1935	— (9.2°)	— —	— (8.9°)	— —
1936	0.1°(10.1°–10.0°)	0.4°(9.6°–9.2°)	0.6°(9.3°–8.7°)	— (8.4°)
1937	0.4°(9.5–9.1°)	0.4°(9.0°–8.6°)	0.3°(8.7°–8.4°)	0.5°(8.3°–7.8°)
Average				
1934	9.2°	9.0°	8.4°	8.2°
1935	9.2°		8.9°	
1936	10.0°	9.4°	9.0°	8.4°
1937	9.2°	8.8°	8.5°	8.1°
Average Gradient				100–250 m.
1934				1.0°(9.2°–8.2°)
1936				1.6°(10.0°–8.4°)
1937				1.1°(9.2°–8.1°)

SEPTEMBER

Range	100 m.	150 m.	200 m.	250 m.
1934	1.2°(10.3°–9.1°)	0.6°(9.5°–8.9°)	0.3°(8.9°–8.6°)	0.4°(8.7°–8.3°)
1935	0.3°(9.8°–9.5°)	0.4°(9.4°–9.0°)	— (8.3°)	0.5°(8.4°–7.9°)
1936	0.6°(10.3°–9.7°)	0.6°(9.8°–9.2°)	0.7°(9.4°–8.7°)	0.7°(8.8°–8.1°)
1937	0.6°(9.8°–9.2°)	— — —	0.1°(8.7°–8.6°)	— — —
Average				
1934	9.6°	9.2°	8.8°	8.5°
1935	9.6°	9.2°	8.3°	8.2°
1936	9.9°	9.5°	9.1°	8.6°
1937	9.5°	—	8.7°	—
Average Gradient				100–250 m.
1934				1.1°(9.6°–8.5°)
1935				1.4°(9.6°–8.2°)
1936				1.3°(9.9°–8.6°)

OCTOBER

Range	100 m.	150 m.	200 m.	250 m.
1934	0.5°(10.2°–9.7°)	0.2°(9.4°–9.2°)	0.4°(8.9°–8.5°)	0.4°(8.5°–8.1°)
1935	0.5°(10.3°–9.8)	0.8°(10.1°–9.3°)	0.7°(9.5°–8.8°)	0.5°(8.6°–8.1°)
1936	0.4°(10.2°–9.8°)	0.4°(9.6°–9.2°)	0.6°(9.4°–8.8°)	0.5°(8.9°–8.4°)
1937	— (10.2°)	— — —	— (8.6°)	— — —
Average				
1934	9.9°	9.3°	8.7°	8.3°
1935	10.0°	9.6°	9.1°	8.4°
1936	10.0°	9.4°	9.0	8.7°
1937	10.2°	—	8.6°	—
Average Gradient				100–250 m.
1934				1.6°(9.9°–8.3°)
1935				1.6°(10.0°–8.4°)
1936				1.3°(10.0°–8.7°)

NOVEMBER

Range	100 m.	150 m.	200 m.	250 m.
1934	0.2°(10.0°–9.8°)	0.4°(9.5°–9.1°)	0.2°(8.8°–8.6°)	0.3°(8.3°–8.0°)
1935	— (9.2°)	— (9.2°)	— (8.8°)	— (8.6°)
1936	1.0°(10.9°–9.9°)	0.6°(9.8°–9.2°)	0.6°(8.8°–8.2°)	0.4°(8.5°–8.1°)
1937	— (9.6°)	— — —	— (8.5°)	— — —
Average				
1934	9.9°	9.3°	8.7°	8.1°
1935	9.2°	9.2°	8.8°	8.6°
1936	10.4°	9.5°	8.6°	8.3°
1937	9.6°	—	8.5°	—
Average Gradient.				100–250 m.
1934				1.8°(9.9°–8.1°)
1935				0.6°(9.2°–8.6°)
1936				2.1°(10.4°–8.3°)

DECEMBER

Range	100 m.	150 m.	200 m.	250 m.
1934	1.5°(10.9°–9.4°)	0.7°(9.8°–9.1°)	0.6°(9.2°–8.6°)	0.4°(8.6–8.2°)
1935	— (10.2°)	— (9.6°)	— (9.0°)	— (8.5°)
1936	1.1°(12.0°–10.9°)	0.5°(10.1°–9.6°)	0.3°(9.1°–8.8°)	0.4°(8.7°–8.3°)
1937	— (10.3°)	— (9.3°)	— (8.8°)	— (8.1°)
Average				
1934	10.2°	9.4°	8.8°	8.3°
1935	10.2°	9.6°	9.0°	8.5°
1936	11.4°	9.8°	8.9°	8.4°
1937	10.3°	9.3°	8.8°	8.1°
Average Gradient.				100–250 m.
1934				1.9°(10.2°–8.3°)
1935				1.7°(10.2°–8.5°)
1936				3.0°(11.4°–8.4°)
1937				2.2°(10.3°–8.1°)

same at 150 m., 200 m., and 250 m. The variability neither decreased nor increased with depth, as can be seen from the fact that it was slightly larger at 150 m. than at 250 m. in about the same number of cases as it was smaller, and that in several cases it was the same at these two depths. On the other hand, the variability increased from 100 m. to the surface, as can be seen from figure 9.

Concerning the gradients between 100 m. and 250 m., Skogsberg (1936: 86) remarked: ". . . it may be stated that by and large the smallest ones were found from April to July, from which period they increased toward the beginning and the end of the year." This statement applies fairly well also to the corresponding gradients of 1934–1937. However, the variations from year to year were so large that they tended to obfuscate this rule. The seasonal rhythm in the thermal gradients between 100 m. and 250 m. was thus about opposite to the one characteristic of the upper 100 m., a fact that stands in close relation to the fundamental pattern in the circulation of the waters of this region, as already noted by Skogsberg (1936: 86). Despite the rhythm, there was a strong mutual resemblance among these curves in the course of each year.

If we examine the monthly averages throughout the year in this stratum, we shall find another rhythm which is best illustrated by figure 16. As can be seen from this figure, this rhythm is of the same general type as the one obtaining in

the upper 100 meters, but it is on a greatly diminished scale. Its most outstanding feature is the spring upwelling which, of course, is expressed in the lowering of the temperatures. It is true that this depression decreases with depth and that it is small at the 250 m. level. Still, it recurs regularly each year. The Davidson Current and the waters of the Oceanic Period probably do not penetrate very deeply; still, the presence of the waters of these periods in the superficial layers evidently has effects which can be traced to considerable depths.

The yearly average temperatures at 150 m., 200 m., and 250 m. for 1932 and 1933 were presented by Skogsberg (1936: 86). They were quite similar to the ones for 1934 and 1936.

	150 m.	200 m.	250 m.
1934.....	8.9°	8.5°	8.0°
1936.....	9.0°	8.5°	8.1°

In regard to the temperature conditions below 250 m. we shall restrict ourselves almost exclusively to a reference to figure 16. A comparison between this figure and figure 28 of Skogsberg (1936) shows a very close resemblance. Evidently thermal conditions in the greater depths are quite constant even though water movements of considerable size occur. As can be seen from figure 16, the upwelling can often be traced well below 250 m. An additional illustration of the thermal conditions in the deeper strata can be found in Phelps (1937: 180).

VI. SUMMARY AND CONCLUSIONS

1. Skogsberg (1936: 14–15) found that the temperatures in the upper 100 meters of Monterey Bay exhibited the following characteristics:

a. "While the monthly average temperatures for this layer may exhibit relatively large differences from one year to another, the vertical thermal distribution is comparatively stable for the individual months, each month having a fairly pronounced pattern."

b. This pattern shows a distinct seasonal progression, expressed mainly by the thermal gradient.

c. "The amplitudes of thermal variation at and near the surface also exhibit a certain seasonal trend, although in a more irregular and obscure manner."

d. Although the seasonal progression of the thermal gradients simulates strikingly the one characteristic of temperate regions, it is brought forth in a nearly opposite manner.

In 1934–1937 these features were also present except that there was no distinct rhythm in the amplitudes of thermal variations at and near the surface (p. 352).

2. The hydrographic conditions in the upper 100 meters in each of the years from 1934 to 1937 were described and depicted (pp. 357–361). The results showed that there was a distinct annual rhythm and that to a different extent in different years the rhythm was warped and obscured by secondary, interfering phenomena, just as during the period 1929–1933. The rhythm, which was described on pp. 361–363, consisted in the annual recurrence of three seasonal phenomena, viz., the Davidson Current, from the middle of November to the middle of February; the upwelling phenomenon, from the middle of February to the latter part of August; and the approach to the coast of relatively warm and clear oceanic water, the so-called Oceanic Period, from the latter part of August to the middle of November.

3. The Davidson Current is a phenomenon characterized by unseasonably warm water and a low thermal gradient. It is a northerly drift of superficial coastal waters. Owing to the rotation of the earth, the water is banked against the coast and a downward and outward flow of the superficial strata is brought about; hence the low thermal gradient. The drift is decidedly variable, not only from year to year but also within each year. See also Skogsberg (1936: 133–135).

4. The oceanic water which enters Monterey Bay in the fall appears to be derived from the California Current, a branch of the Japan Current. The cause of its incoming probably is of a two-fold nature: variations in the strength of the flow of this current and variations in the southerly flow of the superficial, coastal water, a flow which is closely associated with the causation of the upwelling phenomenon. In periods when the southerly flow of the coastal waters is weak and the upwelling phenomenon is greatly reduced or absent, oceanic water enters the bay. The most important period when this happens is at the end of the summer. It is then that what I have called the "Oceanic Period" occurs. However, "relatively warm pulses of oceanic water may enter the Bay on irregularly distrib-

uted occasions nearly throughout the entire year" (see above, p. 362). The period from the end of August to the middle of November has been named *the* "Oceanic Period" because it "occupies a special position among the oceanic pulses on account of its persistence from year to year and due to the fact that in most years it is of fairly large size" (Skogsberg, 1936: 56). For further discussion of this phenomenon, see Skogsberg (1936: 129–133).

5. By far the most important of the three seasonal phenomena in the annual hydrographic rhythm of Monterey Bay is the upwelling phase, i. e., the entrance into the bay of cold water which has welled up from below. Because of its significance and wide-spread distribution along the coast of California, the upwelling phenomenon was submitted to a lengthy discussion by Skogsberg (1936: 120–129). In this summary suffice it to state that the data collected during 1934–1937 were in full agreement with this discussion.

6. The thermal conditions at the surface, 50 m., and 100 m. during 1929–1937, inclusive, were compared (p. 363). The variations in the temperatures at the surface were shown to have been so pronounced and irregular that any talk of a "normal" annual temperature curve for this region can hardly be considered as justifiable (p. 366). On the other hand, at 50 m. and 100 m., the temperature curves were more stable from year to year and they showed pronounced similarities with the "normal" curves drawn for 1929–1933 (Skogsberg, 1936: 62).

7. For the sake of ready comparison, the amounts of water of different degrees of temperature in the upper 100 m. were compared and, on the basis of the records from 1929–1937, indices were computed in the same manner as in Skogsberg (1936: 66, 70, etc.); see pages 367 and 368. The "normal" indices, as well as the deviations from "normality" of the individual months and years, were also calculated. In regard to the monthly deviations, it was found that + and − deviations alternated with each other in an apparently random manner and that the deviations as a rule were rather slight and quite irregular showing no indications of any long-range rhythm (pp. 370 and 371).

8. The amplitudes of thermal variations were studied (p. 371). The maximum amplitude found for the entire period from 1929 to 1937 was 6.8° and this maximum range was recorded at the same station within a period of less than two weeks (p. 372), showing the instability of the waters of this region. The maximum monthly amplitude was 5.8°, a value found in June.

9. The monthly range of thermal variation, the monthly average temperatures, and the monthly average gradients were recorded for the 150 m., 200 m., and 250 m. levels (pp. 373–380). It was found that at each of these depths and for each month the average monthly temperature from 1932 to 1937 did not vary more than 0.9° and that the variability neither increased nor decreased with depth. Furthermore, the thermal rhythm through the year characteristic of the 100 m. level also obtained at the 150 m., 200 m. and 250 m. levels although on a decidedly diminished scale; but it should be noted that the Davidson Current and the Oceanic Period were found to be mostly limited to the superficial strata.

10. In regard to the waters below 250 m., suffice it to state that the upwelling could be traced well below this level; see Skogsberg (1936: 124).

11. The results obtained during 1934–1937 clearly demonstrate that the generalizations reached on the basis of the records collected during 1929–1933 (Skogsberg, 1936) were in all essentials correct. *In this confirmation is probably to be found the main value of the present report.*

APPENDIX

TABLE 1

MONTHLY AVERAGE TEMPERATURES AT STATIONS 4 AND B
(Averages for 1929–1937 include data from station 4, 1929–1930).

Year	Depth in Meters																				
	Surf.	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
JANUARY																					
1934	11.7	11.7	11.6	11.5	11.4	11.3	11.2	11.1	11.1	11.1	11.0	11.0	11.0	10.9	10.8	10.7	10.5	10.4	10.3	10.3	10.2
1935	12.4	12.4	12.4	12.4	12.4	12.4	12.4	12.4	12.3	12.2	12.2	12.1	11.8	11.7	11.3	11.1	10.9	10.8	10.7	10.5	10.4
1936	11.6	11.6	11.6	11.6	10.9	10.8	10.8	10.8	10.7	10.7	10.6	10.6	10.5	10.4	10.1	10.1	10.0	9.9	9.8	9.8	9.6
1937	12.2	12.2	12.2	12.2	12.2	12.2	12.2	12.0	11.9	11.7	11.7	11.6	11.5	11.3	11.1	11.0	10.9	10.8	10.5	10.3	10.1
1934–1937	12.0	12.0	12.0	11.9	11.7	11.7	11.7	11.6	11.5	11.4	11.4	11.3	11.2	11.1	10.8	10.7	10.6	10.5	10.3	10.2	10.1
1929–1937	12.1	12.1	12.1	12.1	12.0	11.9	11.9	11.8	11.8	11.7	11.6	11.5	11.4	11.3	11.1	11.0	10.9	10.8	10.7	10.6	10.4
FEBRUARY																					
1934	12.4	12.4	12.3	12.2	12.1	12.0	12.0	11.9	11.8	11.8	11.7	11.6	11.5	11.3	11.2	11.1	11.0	10.6	10.4	10.0	9.8
1935	12.2	12.2	12.2	12.2	12.2	12.1	12.1	11.9	11.8	11.7	11.3	11.2	11.1	11.0	10.8	10.6	10.4	10.2	10.0	9.9	9.6
1936	12.4	12.5	12.5	12.5	12.4	12.4	12.4	12.3	12.3	12.2	12.2	12.1	12.0	11.9	11.8	11.7	11.4	11.1	10.8	10.7	10.6
1937	10.7	11.0	11.0	11.0	11.0	11.0	10.9	10.9	10.9	10.8	10.7	10.7	10.6	10.4	10.3	10.2	10.2	10.1	10.1	9.9	9.8
1934–1937	11.9	12.0	12.0	12.0	11.9	11.9	11.9	11.8	11.7	11.6	11.5	11.4	11.3	11.2	11.0	10.9	10.8	10.5	10.3	10.1	10.0
1929–1937	12.1	12.1	12.1	12.0	11.9	11.9	11.8	11.8	11.7	11.6	11.5	11.4	11.3	11.1	11.0	10.9	10.8	10.6	10.5	10.3	10.2
MARCH																					
1934	13.2	13.0	12.7	12.4	12.0	11.6	11.4	10.9	10.7	10.4	10.3	10.1	10.0	9.8	9.7	9.5	9.3	9.2	9.2	9.1	9.1
1935	11.7	11.7	11.7	11.6	11.4	11.1	10.9	10.8	10.8	10.6	10.2	10.0	9.9	9.8	9.6	9.5	9.4	9.3	9.2	9.2	9.1
1936	12.6	12.5	11.8	11.4	10.9	10.8	10.7	10.6	10.5	10.4	10.3	10.2	10.1	10.0	9.9	9.7	9.5	9.5	9.4	9.4	9.4
1937	11.7	11.6	11.6	11.4	11.3	11.2	11.1	11.0	10.9	10.8	10.6	10.4	10.3	10.1	10.0	9.9	9.7	9.6	9.5	9.4	9.3
1934–1937	12.3	12.2	12.0	11.7	11.4	11.2	11.0	10.8	10.7	10.6	10.4	10.2	10.1	9.9	9.8	9.7	9.5	9.4	9.3	9.3	9.2
1929–1937	12.2	12.1	11.8	11.5	11.3	11.1	10.9	10.7	10.6	10.4	10.2	10.1	10.0	9.9	9.8	9.6	9.5	9.4	9.3	9.3	9.2
APRIL																					
1934	11.6	11.5	11.4	11.1	10.7	10.2	9.7	9.6	9.5	9.4	9.3	9.3	9.2	9.1	9.0	8.9	8.8	8.8	8.8	8.8	8.7
1936	11.6	11.5	10.4	11.1	10.3	10.2	9.8	9.6	9.5	9.5	9.5	9.4	9.1	9.1	9.1	9.0	8.9	8.8	8.7	8.7	8.6
1937	11.0	11.0	10.7	10.6	10.5	10.5	9.7	9.5	9.4	9.2	9.0	8.8	8.6	8.6	8.6	8.5	8.5	8.3	8.2	8.1	8.1
1934–1937	11.4	11.3	11.2	10.9	10.5	10.3	9.7	9.6	9.5	9.4	9.3	9.2	9.0	8.9	8.9	8.8	8.7	8.6	8.6	8.5	8.5
1929–1937	11.8	11.6	11.4	11.1	10.6	10.3	10.0	9.8	9.7	9.6	9.4	9.3	9.2	9.1	9.0	9.0	8.9	8.9	8.8	8.7	8.7

TABLE 1a

MONTHLY AVERAGE TEMPERATURES AT STATIONS 4 AND B
(Averages for 1929–1937 include data from station 4, 1929–1930.)

Year	Depth in Meters																			
	Surf.	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
MAY																					
1934	12.6	12.3	11.8	11.3	10.6	10.3	9.9	9.8	9.7	9.4	9.4	9.4	9.4	9.3	9.3	9.2	9.1	9.1	9.0	9.0	8.9
1936	11.7	11.6	11.2	10.8	10.2	9.7	9.6	9.5	9.3	9.3	9.2	9.2	9.1	9.1	9.1	9.0	8.8	8.8	8.8	8.7	8.6
1937	10.9	10.7	10.4	10.0	9.9	9.6	9.3	9.1	8.9	8.8	8.8	8.8	8.7	8.6	8.5	8.5	8.5	8.5	8.4	8.4	8.4
1934–1937	11.7	11.5	11.1	10.7	10.2	9.9	9.6	9.5	9.3	9.2	9.1	9.1	9.1	9.0	9.0	8.9	8.8	8.8	8.7	8.7	8.6
1929–1937	12.3	12.1	11.6	10.9	10.4	10.1	9.8	9.6	9.5	9.4	9.3	9.3	9.2	9.1	9.0	9.0	8.9	8.8	8.8	8.7	8.7
JUNE																					
1934	12.3	12.0	11.5	10.8	10.5	10.2	9.8	9.5	9.3	9.3	9.2	9.2	9.1	9.1	9.0	8.9	8.8	8.8	8.7	8.6	8.6
1936	13.7	13.4	12.8	11.1	10.4	10.4	10.1	9.9	9.6	9.5	9.3	9.2	9.1	9.1	9.0	8.9	8.8	8.7	8.6	8.5	8.5
1937	13.2	12.9	12.5	11.3	10.6	10.0	9.9	9.8	9.7	9.6	9.6	9.4	9.4	9.3	9.2	9.1	9.1	8.9	8.8	8.8	8.7
1934–1937	13.1	12.8	12.3	11.1	10.5	10.2	9.9	9.7	9.5	9.5	9.4	9.3	9.2	9.2	9.1	9.0	8.9	8.8	8.7	8.6	8.6
1929–1937	13.0	12.7	12.1	11.3	10.8	10.5	10.2	9.9	9.7	9.6	9.4	9.2	9.1	9.1	9.0	8.9	8.8	8.8	8.7	8.6	8.6
JULY																					
1934	12.7	12.5	11.4	10.9	10.7	10.5	10.4	10.2	10.0	9.9	9.9	9.8	9.8	9.7	9.6	9.5	9.4	9.3	9.2	9.2	9.1
1936	11.4	10.8	10.4	10.0	9.8	9.6	9.5	9.4	9.3	9.2	9.1	9.0	8.9	8.9	8.9	8.8	8.7	8.7	8.7	8.7	8.6
1937	13.4	13.0	12.8	12.2	11.5	11.2	10.9	10.7	10.5	10.4	10.2	10.1	10.0	9.8	9.7	9.6	9.5	9.4	9.3	9.2	9.2
1934–1937	12.5	12.1	11.5	11.0	10.7	10.4	10.3	10.1	9.9	9.8	9.7	9.6	9.6	9.5	9.4	9.3	9.2	9.1	9.1	9.0	9.0
1929–1937	12.9	12.5	11.9	11.2	10.8	10.5	10.3	10.2	10.0	9.8	9.7	9.5	9.4	9.3	9.3	9.2	9.2	9.1	9.0	9.0	9.0
AUGUST																					
1934	13.2	12.5	12.1	11.8	11.3	11.0	10.4	10.2	10.2	10.1	9.9	9.9	9.8	9.7	9.7	9.5	9.4	9.4	9.3	9.3	9.2
1936	14.4	14.1	13.5	13.0	12.6	12.2	12.0	11.6	11.0	10.9	10.8	10.7	10.6	10.5	10.3	10.2	10.2	10.2	10.1	10.0	10.0
1937	14.5	14.2	13.3	12.4	12.2	11.5	11.1	10.9	10.6	10.4	10.3	10.2	10.1	9.9	9.9	9.8	9.7	9.7	9.5	9.4	9.3
1934–1937	14.0	13.6	13.0	12.4	12.0	11.6	11.2	10.9	10.6	10.5	10.3	10.3	10.2	10.0	10.0	9.8	9.8	9.8	9.6	9.6	9.5
1929–1937	13.8	13.4	12.6	12.0	11.5	11.1	10.9	10.7	10.5	10.4	10.3	10.2	10.1	10.0	9.9	9.8	9.7	9.7	9.6	9.5	9.5

TABLE 1b

MONTHLY AVERAGE TEMPERATURES AT STATIONS 4 AND B
(Averages for 1929–1937 include data from station 4, 1929–1930.)

Year	Depth in Meters																			
	Surf.	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
SEPTEMBER																					
1934	14.0	13.2	13.0	12.7	12.5	12.1	11.6	11.4	11.3	11.1	10.9	10.8	10.5	10.2	10.1	10.0	9.9	9.9	9.8	9.7	9.6
1935	14.0	13.9	13.2	13.0	12.1	11.8	11.7	10.8	10.6	10.4	10.2	10.2	10.1	10.1	10.1	10.0	9.9	9.9	9.8	9.8	9.6
1936	14.6	14.6	13.4	13.1	12.7	12.4	12.1	11.9	11.8	11.6	11.4	11.2	11.1	10.9	10.8	10.7	10.5	10.4	10.3	10.2	10.0
1937	13.1	12.8	12.5	11.4	11.2	10.9	10.6	10.4	10.2	10.2	10.1	10.1	10.1	10.0	9.9	9.9	9.9	9.9	9.9	9.9	9.9
1934–1937	13.9	13.6	13.0	12.6	12.1	11.8	11.5	11.1	11.0	10.8	11.7	10.6	10.5	10.3	10.2	10.2	10.1	10.0	10.0	9.9	9.8
1929–1937	14.4	14.0	13.4	12.9	12.5	12.0	11.7	11.3	11.1	10.9	10.7	10.5	10.4	10.2	10.2	10.1	10.1	10.0	9.9	9.8	9.7
OCTOBER																					
1934	13.7	13.6	13.2	13.0	12.9	12.5	12.2	12.1	12.0	11.8	11.7	11.6	11.5	11.3	11.1	10.8	10.6	10.4	10.2	10.0	9.8
1935	13.8	13.7	13.6	13.4	13.0	12.6	12.1	11.8	11.5	11.3	11.1	11.1	10.9	10.8	10.6	10.6	10.5	10.4	10.3	10.2	10.0
1936	14.8	14.5	13.9	13.7	13.4	13.0	12.9	12.6	12.4	12.1	11.9	11.6	11.4	11.1	11.0	10.8	10.7	10.4	10.3	10.3	10.1
1937	14.4	14.0	13.7	13.0	12.1	11.9	11.7	11.6	11.4	11.3	11.2	11.1	11.0	11.0	10.9	10.9	10.9	10.8	10.7	10.6	10.5
1934–1937	14.2	14.0	13.6	13.3	12.9	12.5	12.2	12.0	11.8	11.6	11.5	11.4	11.2	11.1	10.9	10.8	10.7	10.5	10.4	10.3	10.1
1929–1937	13.7	13.4	12.9	12.4	12.0	11.7	11.5	11.2	11.0	10.8	10.7	10.5	10.7	10.3	10.2	10.1	10.0	10.0	10.0	9.8	9.7
NOVEMBER																					
1934	13.8	13.7	13.5	13.5	13.4	13.3	13.2	13.0	12.5	11.8	11.5	11.2	11.0	10.8	10.7	10.5	10.3	10.2	10.0	10.0	9.9
1935	12.1	12.0	11.8	11.7	11.6	11.6	10.6	10.3	10.0	9.8	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.5	9.5	9.5
1936	14.5	14.5	14.5	14.3	14.1	13.8	13.6	13.1	12.8	12.5	12.2	11.9	11.8	11.6	11.5	11.4	11.3	10.9	10.7	10.6	10.4
1937	15.3	15.3	14.9	14.6	14.1	13.8	13.6	13.3	13.2	12.8	12.3	11.6	11.1	10.8	10.6	10.4	10.3	10.3	10.2	10.0	9.9
1934–1937	13.9	13.9	13.7	13.5	13.3	13.1	12.8	12.4	12.1	11.7	11.4	11.1	10.9	10.7	10.6	10.5	10.4	10.3	10.1	10.0	9.9
1929–1937	13.1	13.1	12.9	12.7	12.5	12.3	12.0	11.8	11.7	11.4	11.2	10.8	10.7	10.5	10.5	10.4	10.3	10.2	10.0	9.9	9.8
DECEMBER																					
1934	13.2	13.2	13.2	13.1	12.8	12.5	12.4	12.3	12.1	11.9	11.6	11.4	11.2	11.0	10.9	10.7	10.5	10.3	10.2	10.1	10.0
1936	14.1	14.1	14.1	14.0	13.9	13.7	13.6	13.5	13.4	13.3	13.2	13.1	12.9	12.6	12.5	12.4	12.4	12.1	11.9	11.7	11.5
1937	13.7	13.8	13.8	13.7	13.7	13.5	13.3	13.2	13.1	13.0	12.8	12.7	12.7	12.1	11.9	11.6	11.3	11.0	10.6	10.4	10.2
1934–1937	13.7	13.7	13.7	13.6	13.5	13.2	13.1	13.0	12.9	12.7	12.5	12.4	12.3	11.9	11.8	11.6	11.4	11.1	10.9	10.7	10.6
1929–1937	13.0	13.0	12.9	12.9	12.8	12.6	12.5	12.5	12.4	12.3	12.1	11.8	11.7	11.5	11.4	11.3	11.1	10.9	10.8	10.6	10.5

TABLE 2

Amounts of Water of Different Temperatures in 1931–1937

1931

Temp.	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
16°												
15°					0.7	1.1	1.0	0.7	1.5			
14°		25.0		0.2	2.3	9.4	0.4	5.0	5.9	0.4		
13°	63.3	55.1	14.7	1.3	15.0	8.0	1.9	9.4	9.2	7.7	3.4	
12°	34.3	8.6	16.5	14.0	13.0	6.1	4.7	9.0	11.3	12.7	14.7	28.1
11°	2.4	3.3	18.2	16.5	14.6	7.3	6.4	11.4	21.2	29.7	32.5	62.6
10°		8.0	20.9	22.0	21.6	11.4	28.4	29.7	30.4	44.6	46.5	9.2
9°			24.7	40.3	30.3	47.9	51.0	34.9	20.5	4.9	2.9	
8°			5.0	5.5	2.6	8.7	6.1					

1932

Temp.	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
16°								0.4	13.0	2.4		
15°								3.0	4.2	3.4		
14°							2.0	0.4	7.6	2.8		
13°					1.4	0.5	3.7	4.6	7.6	3.2	2.7	8.2
12°	18.2				11.4	10.0	5.2	8.6	6.3	7.6	8.0	19.3
11°	41.3	34.0	20.7	11.0	8.0	15.0	7.5	12.2	7.2	15.6	15.3	62.5
10°	38.7	42.8	26.3	19.2	10.8	8.7	11.3	39.2	54.2	46.0	62.3	7.5
9°	1.8	23.2	33.0	40.3	45.2	37.0	65.2	31.6		19.0	11.7	2.5
8°			20.0	29.5	23.2	28.8	5.0					

1933

Temp.	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
16°												
15°												
14°									2.7			
13°								4.2	5.8	0.2	0.5	
12°							5.0	9.0	7.0	6.3	6.2	
11°	54.0	8.7	10.0	5.0		6.7	7.0	3.8	11.7	26.0	13.3	25.0
10°	36.0	60.0	36.8	16.3	19.8	15.7	12.2	13.5	23.0	17.0	37.0	55.7
9°	10.0	14.0	29.5	18.7	19.6	24.0	41.2	59.5	42.0	49.7	43.0	19.3
8°		17.3	23.7	60.0	48.6	40.3	34.6	10.0	7.8	0.8		
7°					12.0	13.3						

1934

Temp.	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
16°												
15°												
14°			0.2		3.0			0.3	5.0	5.0	6.7	3.7
13°		3.7	3.5		1.0		0.5	2.7	8.7	11.0	23.3	17.0
12°	20.0	28.0	18.2	2.7	4.5	4.7	7.5	7.0	13.2	25.0	12.7	16.0
11°	31.7	33.9	12.8	10.5	2.5	9.3	5.0	17.3	15.2	28.0	15.0	27.7
10°	27.0	30.2	21.2	18.3	18.0	11.3	39.0	28.7	33.0	24.0	30.7	24.3
9°	21.2	4.1	38.5	36.0	51.0	49.7	33.0	35.7	25.0	7.0	11.7	11.2
8°			5.5	32.5	20.0	25.0	15.0	8.3				

1935

Temp.	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
16°												
15°												
14°									3.0	8.2		
13°									12.5	10.0		
12°	65.5	36.7							9.0	13.0	5.0	
11°	14.5	23.0	31.0						6.0	30.8	23.0	
10°	7.5	27.8	24.0						39.5	33.0	12.0	
9°	12.5	12.5	45.0						30.0	5.0	60.0	
8°												

1936

Temp.	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
16°						0.7						
15°						2.3			4.0	0.7	5.0	
14°						3.7		10.0	3.2	10.0	15.3	15.5
13°			2.5			1.7		7.5	8.5	17.7	15.7	39.0
12°		52.0	5.0	6.0	1.0	1.7		8.0	19.5	17.0	23.7	36.0
11°	34.0	41.0	11.0	5.7	11.7	4.3	2.7	22.0	27.5	24.7	21.0	8.2
10°	48.5	7.0	45.0	15.0	6.5	15.3	15.0	37.5	32.7	28.3	19.3	1.2
9°	17.5		36.5	51.7	51.5	38.7	39.0	15.0	4.5	1.7		
8°				21.7	29.2	31.7	43.3					

1937

Temp.	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
16°											8.0	
15°							2.4	5.7		5.0	14.0	
14°												
13°	13.7					4.0	2.6	7.7	2.0	10.0	20.0	45.0
12°	36.2					7.3	13.8	5.0	10.0	7.0	10.0	22.0
11°	23.7	33.3	29.0	4.0	1.6	6.7	16.0	13.0	11.0	43.0	10.0	18.0
10°	10.2	54.0	44.2	29.5	15.6	16.7	21.6	42.0	42.0	35.0	33.0	15.0
9°	14.7	12.7	24.3	12.5	27.4	44.3	34.0	26.7	35.0		5.0	
8°	1.2		2.5	54.0	55.4	21.0	9.6					

TABLE 3

MONTHLY AMPLITUDES OF TEMPERATURE AND MONTHLY AVERAGE AMPLITUDES FOR 1931–1937

Surface	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
1931	0.7°	0.8°	1.9°	3.5°	2.0°	3.4°	4.7°	2.6°	1.5°	2.3°	2.2°	1.1°
1932	0.6°	0.7°	0.9°	0.4°	1.1°	0.5°	3.0°	4.2°	2.1°	4.5°	1.5°	1.8°
1933	0.6°	0.8°	0.7°	0.8°	0.6°	1.4°	1.3°	1.1°	1.3°	1.8°	2.1°	1.0°
1934	1.1°	1.4°	1.4°	1.8°	4.5°	1.1°	0.7°	2.6°	1.6°	1.7°	0.5°	1.8°
1935	0.8°	1.7°	0.1°						0.5°	2.5°		
1936	0.4°	0.3°	0.8°	2.1°	0.8°	5.8°	1.0°	0.4°	1.9°	0.7°	1.1°	0.5°
1937	2.3°	0.8°	0.8°	0.8°	1.1°	0.7°	1.0°	0.9°				
Ave. 1931–1937	0.9°	0.9°	0.9°	1.6°	1.7°	2.1°	2.1°	2.0°	1.5°	2.2°	1.5°	1.2°
0–50 m.	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
1931	0.7°	0.8°	3.0°	2.7°	2.5°	2.6°	1.8°	2.4°	1.8°	1.1°	1.6°	0.8°
1932	1.1°	0.5°	1.7°	0.6°	0.6°	0.6°	1.6°	3.6°	2.3°	3.1°	0.9°	1.4°
1933	0.8°	1.5°	1.2°	0.6°	0.5°	1.1°	0.7°	0.3°	0.6°	1.6°	1.5°	0.9°
1934	1.6°	1.7°	0.8°	1.3°	1.5°	0.4°	0.8°	1.3°	2.3°	1.6°	1.3°	2.5°
1935	0.9°	1.5°	0.4°						0.5°	1.0°		
1936	0.5°	0.5°	0.3°	1.0°	0.6°	2.2°	0.6°	1.1°	1.6°	0.5°	1.1°	0.7°
1937	2.6°	0.2°	0.9°	0.2°	1.0°	0.9°	1.5°	1.0°				
Ave. 1931–1937	1.2°	1.0°	1.2°	1.1°	1.1°	1.3°	1.2°	1.6°	1.5°	1.5°	1.3°	1.3°
50 m.	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
1931	0.8°	1.7°	2.8°	3.4°	3.5°	1.5°	1.5°	2.2°	2.0°	1.3°	1.5°	0.8°
1932	1.4°	0.9°	2.4°	0.8°	0.8°	0.9°	0.4°	2.0°	0.7°	1.3°	0.7°	0.8°
1933	1.2°	2.0°	1.4°	0.4°	0.6°	1.3°	0.4°	0.7°	0.8°	1.8°	0.9°	1.2°
1934	2.1°	2.1°	0.7°	1.2°	0.6°	0.3°	0.7°	1.4°	1.7°	1.1°	1.5°	2.4°
1935	1.1°	2.2°	0.4°						0.5°	0.5°		
1936	0.7°	0.7°	0.2°	0.4°	0.2°	0.8°	0.2°	0.9°	2.0°	0.6°	0.9°	0.7°
1937	3.7°	0.5°	0.9°	1.0°	1.2°	1.2°	2.1°	0.2°				
Ave. 1931–1937	1.6°	1.4°	1.3°	1.2°	1.1°	1.0°	0.9°	1.2°	1.3°	1.1°	1.1°	1.2 °
50–100 m.	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
1931	0.9°	3.5°	2.1°	3.0°	1.3°	0.8°	1.2°	1.5°	1.8°	0.7°	0.7°	1.7°
1932	1.0°	1.3°	1.7°	0.5°	0.4°	0.5°	0.2°	1.3°	0.6°	1.1°	0.5°	0.9°
1933	1.4°	1.8°	1.5°	0.4°	0.7°	0.9°	0.8°	0.5°	0.8°	1.7°	0.8°	1.2°
1934	2.0°	1.2°	0.7°	0.5°	0.7°	0.4°	0.9°	0.9°	1.5°	0.8°	0.7°	1.7°
1935	2.6°	1.9°	0.2°						0.3°	1.2°		
1936	1.0°	0.0°	0.2°	0.3°	0.2°	0.8°	0.2°	0.7°	0.8°	0.5°	0.8°	0.9°
1937	2.6°	0.8°	1.0°	0.3°	0.7°	0.8°	1.3°	0.4°				
Ave. 1931–1937	1.6°	1.5°	1.1°	0.8°	0.7°	0.7°	0.8°	0.9°	1.0°	1.0°	0.7°	1.3°
100 m.	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
1931	1.7°	4.0°	1.8°	1.9°	0.8°	0.8°	1.3°	1.0°	1.2°	0.6°	0.6°	2.1°
1932	0.8°	1.1°	1.6°	0.4°	0.4°	1.0°	0.1°	1.1°	0.1°	1.1°	0.8°	1.6°
1933	1.7°	1.5°	1.7°	0.3°	0.6°	0.9°	1.0°	0.2°	0.9°	1.9°	0.4°	0.9°
1934	1.8°	0.8°	0.6°	0.4°	0.4°	0.7°	0.5°	1.2°	1.5°	0.5°	0.8°	1.4°
1935	3.0°	1.2°	0.3°						0.2°	0.9°		
1936	0.8°	0.8°	0.2°	0.3°	0.3°	0.7°	0.5°	0.8°	0.3°	0.5°	0.3°	1.2°
1937	2.0°	0.7°	0.7°	0.0°	0.8°	0.8°	0.9°	0.5°				
Ave. 1931–1937	1.7°	1.4°	1.0°	0.5°	0.5°	0.8°	0.7°	0.8°	0.7°	0.9°	0.5°	1.4°

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(For further bibliographical references, see the latter paper.)

THE AMERICAN PHILOSOPHICAL SOCIETY AND ITALY*

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I. THE AGE OF BENJAMIN FRANKLIN

THE implications of the subject announced by this paper are too numerous and extensive to permit a complete treatment at the present time; for, while the main tie between the American Philosophical Society and Italy has been that universal element of rationality which science presents in the least beclouded form, yet myriad other threads of a social, literary, artistic, and political nature appear, the sum of which is a remarkable segment of the cultural bond that has linked Italy and the United States during the last two centuries. This monograph can pretend only to introduce the general subject, with a comparatively full treatment of the eighteenth century, which offers perhaps the most interesting grist for our mill. Other seemingly arbitrary or opportune emphases are calculated to suggest the more important and characteristic aspects of the topic. Projected studies will supply the detail of the present canvass by developing the role played by particular members of the American Philosophical Society—both American and Italian—as ambassadors in the Italo-American cultural exchange, the agenda being inevitably headed by the founder of the American Philosophical Society and the dean of American cosmopolitans, Benjamin Franklin.

The intellectual activity of the eighteenth century, which saw the birth of the American Philosophical Society, presents a distinctive common denominator on both sides of the Atlantic: a lively interest in science which, with the general adoption of the Newtonian approach to the physical world, was revealing vast new horizons; and an impelling desire on the part of investigators to pool their talents and resources in societies which would result in mutual stimulation and afford more effective means of divulging their discoveries. No better proof exists that science early enjoyed in the colonies a vogue comparable to that in Europe than the experimental lectures which in the first part of the eighteenth century became a standard element in the amusement, if not the edification, of every American city of any size.[1] Although the roots of the American Philosophical Society are traceable to Franklin's activity before the middle of the century, the full flowering of American science does not come about until somewhat later, during the last three decades. Subsequent events show that scientific America attained its majority in 1769 with the fusion of the American Society for Promoting and Propagating Useful Knowledge Held in Philadelphia with the older American Philosophical Society, and before the end of the century this new self-consciousness and self-confidence were reflected in the rise of similar organizations in Boston and elsewhere.

That these first American institutions should be oriented Europe-ward was inevitable at a time when the colonists looked upon themselves as good Englishmen. Despite their first and strongest sympathy with English science, it became very quickly apparent that the intellectual life of America would not be restricted by political confines. Motivated by that typical eighteenth-century patriotism whose allegiance was to all humanity, confident that their offerings were of real value to mankind, the Americans soon began to make modest, but firm, bids for recognition. The American Philosophical Society was the first of the American organizations to manifest this spirit in word and deed, and the policy for which the precedent was set in those early days has remained essentially unaltered to the present day, with implications for Italy which we shall soon survey; but keeping in mind that Italy is just one case in point, and that similar studies should be made for Russia, Sweden, Denmark, Holland, France, Spain, and Portugal, not to mention certain South American nations.[2]

* A grant from the American Philosophical Society made this investigation possible.

[1] Faÿ, B., *Franklin, the apostle of modern times*, 206–207, Boston, Little, Brown, 1929.

[2] The present article is necessarily adumbrated to some extent by Professor Gilbert Chinard, The American Philosophical Society and the world of science (1768–1800), *Proc. Amer. Philos. Soc.* **87**: 1–11, 1944; the beginning

The dominant note of cosmopolitanism and philosophic altruism which distinguishes the activity of the American Philosophical Society in the period 1770–1800 struck a responsive chord in Italy, for there, too, men were bending their energies, singly and collectively, to expand the horizons of knowledge, inspired by the same faith in the ultimate perfection of rational and social humanity. In the halcyon days following Aix-la-Chapelle (1748) and prior to the turmoils of Revolution and Risorgimento, many of the older Italian academies adopted new programs more consonant with the times, and numerous new academies were created.[3] Tempered to the Galilean-Newtonian scientific attitude, with a marked bent to the useful prompted by the first audible stirrings of the industrial revolution, they spoke the same intellectual language as the American Philosophical Society. And, like that of the American Philosophical Society, the scope of these organizations transcended political boundaries, with provisions for collaboration with similar foreign institutions and for the election of foreign correspondents.

The remarkable esprit de corps that prevailed among the savants of western civilization in the eighteenth century led to frequent personal relations. We shall soon see that most of the Italians associated with the American Philosophical Society in this first period had known Franklin in Europe, that several of them visited America where they struck up friendships with other members of the American Philosophical Society, and that in general they took seriously their responsibilities as correspondents. Americans and Italians shared membership in such prominent intellectual clearing houses as the Royal Society and the Parisian Académie des Sciences. Franklin, whose fame in Italy had been established well before 1769 by his electrical experiments and by the invention of the stove which still today is known there simply by his name, was made a member of four—possibly five—Italian scientific societies. Benjamin Rush was elected to membership in at least two. Even before the crystallization of the American Philosophical Society, John Morgan, later surgeon-general of the American revolutionary army, today remembered chiefly as the founder of the first medical school in America, had undertaken, in 1764, a tour of Italy in which he met some of the most famous Italian scientists and physicians, and incidentally obtained admission, *mirabile dictu*, into the Roman Accademia degli Arcadi—an event that may not be lacking in serious implications.[4] It is the personal element which renders so vibrant this Golden Age in the scientific relations between America and Italy; but being in large measure attributable to the presence of that genial citizen of the world, Benjamin Franklin, this happy characteristic loses much of its intensity after his death. One cannot over-emphasize the part played by Franklin in this first phase of Italo-American intercourse; for relations with Italy, a country until recent times divided politically and culturally, rigorously controlled by jealous foreign powers, generally isolated from America by reason of tongue, have hinged upon personalities to a much greater extent than is true for England or France, for example.

The first bit of evidence of unquestioned significance for the present study to be found in the official documents of the American Philosophical Society appears in the Minutes[5] of the freshly amalgamated Society under the date 16 January 1769. Note is there taken of

> . . . a letter from D. Cirillo of Naples to Doct.r J. Morgan thanking him for having proposed him a Member of the Society[6] and promising to do anything in his power that may be of use to promote the Ends for which the Society was instituted, and intimating that they have in Italy "a great many Trees, fruits and plants of different kinds, which are of great use to human Life and which may be easily introduced into America: That in the Kingdom of Naples are several plants very good for making arti-

of a parallel investigation for France is J. G. Rosengarten, The early French members of the American Philosophical Society, *Proc. Amer. Philos. Soc.* **46**: 87–93, 1907.

[3] Maylender, M., *Storia delle accademie d'Italia*, 5 v., *passim*, Bologna, Cappelli, [1926–1930].

[4] See Pace, A., Notes on Dr. John Morgan and his relations with Italian men and women of science, in *Bull. Hist. Med.* **18**: 445–453, 1945.

John Galt, in his *Life, studies, and works of Benjamin West, Esq.* I: 144, London, 1820, informs us that the well known American painter, eventually a member of the American Philosophical Society, had in the early 1760's been received into academies at Parma, Florence, and Bologna. In all likelihood these were academies of the fine arts.

[5] The Minutes of the American Philosophical Society as published in the *Proceedings*, and, beginning with 1937, in the *Year Book*, proved unsatisfactory for the purposes of this investigation, and recourse to the original MSS. was necessary.

[6] In view of the inevitable slowness of the means of communications in those days, the allusion must be to the older American Society, of which John Morgan was a member until it fused with the Philosophical Society in January 1769.

ficial Grass and especially one called by the Botanists Hedysanum coronarium; this plant in the spring and summer affords the best green food for many animals & in the winter time makes very good hay."

During his visit in Italy in 1764, Dr. John Morgan had spent some time in Naples. There is little doubt that while in that city he associated with Cirillo, whom he may have known previously in England as a fellow-student under the famous physician, William Hunter.[7] Although no explicit evidence seems to exist that Cirillo became a member of the American Philosophical Society, a fact which may explain why he does not appear on any of the official membership lists, nevertheless one would like to think that the roster of forty odd Italian members of the American Philosophical Society elected to the year 1946 was in fact graced—perhaps headed—by the name of that eminent physician and botanist,[8] honored friend of Franklin,[9] and destined for a noble death on the scaffold in 1799 for his part in the premature Parthenopean revolution of that year in Naples.

Early in 1771 the American Philosophical Society, the proud parent of its first volume of *Transactions*, decided to enter upon official relations with organizations of similar aims in Europe. Accordingly on the first of February it was resolved to send a copy to "each of the foreign Philosophical Societies," and on the twenty-second of the same month the committee that had been appointed "to bring in a List of the most considerable Philosophical Societies in Europe" reported nearly a score of institutions, including "The Academy of Bononia, the Academy of Siences at Turin, Academy at Florence." The future role of Benjamin Franklin as the main link between the American Philosophical Society and Europe is apparent in the order of 18 October 1771—"That the Copies of the Transactions designed for the Foreign Societies and Universities be sent without Loss of Time, by the Secretaries, to Dr. Franklin." Despite the enjoinder to speed, it was 15 May 1772 before the Secretaries could report that the volumes were on their way, when we are told further that:

> The following Address was prefix'd to each Volume designed for the above mentioned Institutions—
>
> The American Philosophical Society held at Philadª humbly desirous to cooperate wᵗʰ [the Societys Name] in their laudable Endeavers for the Advancement of useful Knowlege, request yᵉ learned & respectable Body to accept yᵉ Vol. as the first Fruits of their Labors in this new World.
>
> By order of the Society
>
> WILLIAM SMITH
> ROBT. STRETTELL JONES } Secretaries

The earliest and most enthusiastic recognition of the first fruits of its labors to reach the American Philosophical Society came from Italy through the intermediary of the well known Americanophile, Philip Mazzei:

> 7. December 1773
> RICHMOND
>
> SIRS, I had the honour to deliver to the Accademies of Turin & Bologna in Italy & to the Grand-Duke of Tuscany the first Volume of the Transactions of the American Philosophical Society, which Dr. Franklin gave me for that purpose in London. Inclosed you will find the answers from Bologna & Florence, and the copy of that from Turin, as the original of it is in one of the 4. Volumes I had from that Accademy for the American Society. The said 4. Volumes I shall take the first opportunity to forward to you as soon as you will please to let me know by what channel I am to send them. I have likewise 3. pamphlets written by Mr. Fontana, who has written many more, & every one containing some discoveries, but he could not find the others at that time, & has promised to send them by the first opportunity. I shall reside in Virginia, & as I have engaged to forward to you whatever may be hereafter committed to my care from that part of the World, So I shall esteem it a particular honour at all times to be employed by the American Philosophical Society in the like service. I am with Profound Respect,
>
> Sirs,
>
> Your most Obedient & most Humble Servant
> PHILIP MAZZEI

[7] *Cf.* S. Ticozzi's continuation of Corniani, G. B., *I Secoli della letteratura italiana* II: 456, 1833.

[8] It is very likely that Cirillo was automatically admitted by virtue of membership in the antecedent American Society. Morgan would scarcely have mentioned the nomination to his friend were not election to the American Society a *fait accompli*. The lack of elective action on the part of the new American Philosophical Society, the tenor of Cirillo's letter, including the allusion to Morgan's having proposed his name to the American Society, and the very presence of the substance of Cirillo's communication in the Minutes of the American Philosophical Society, are other signs that point uniformly in the same direction.

John Morgan may likewise be responsible for the "Signor Famitz, of Naples," who had been duly elected to the old American Society on 15 April 1768, becoming *ipso facto* a member of the future American Philosophical Society. It has been to date impossible to establish the identity of Famitz.

[9] Salfi, F., Éloge de Filangieri, prefixed to G. Filangieri: *Oeuvres . . . traduites de l'italien* I: cix, nouv. éd., accompagnée d'un commentaire, par B. Constant . . . Paris, 1822.

The action taken by the American Philosophical Society in ordering the letter of Mazzei and the messages which he transmitted from the academies of Bologna, Florence, and Turin inserted, with translations, in the Minutes of 5 January 1774 expresses more eloquently than words the gratification felt at the reception accorded their overture. On the other hand, the letters from Florence, Turin, and Bologna transmitted by Mazzei bespeak a keen desire on the part of the Italians to undertake relations with a society that gave promise of being a reliable source of information regarding the New World.[10]

Meantime the volume had aroused widespread acclaim in Italy. As early as February 1772 the important *Novelle letterarie* of Florence had introduced the work in the most laudatory terms:[11]

> Here is the first scientific product of the Americans united in the form of an academic society. We Europeans, after the restoration of letters, had to begin with the less profound studies of languages and humanity based on the books of the ancient classics; where, in the New World, to which our knowledge has been transported, they begin at once with a philosophic academy.

An unreserved expression of the importance attached by the Italians to the emergence of the new American society whose existence had just been announced by its first volume of *Transactions* is a note that appeared in the widely diffused *Giornale de' letterati di Pisa* for the year 1773:[12]

> This nascent Academy appears under the auspices and presidency of the immortal Benjamin Franklin with all the luster of the most ancient and considerable philosophical societies, to none of whom need it repute itself inferior, both for the wise laws governing its recent establishment, and for the surprising number of members who compose it, and more especially because of the learned and interesting memoirs with which it has enriched this its first volume.

The notice then goes on to review very briefly the contents of that memorable initial volume of *Transactions*, closing with the following words:

> The learned English nation has indeed cause to be proud of the brilliant progress of a colony sent to humanize those wild regions. And while the establishment of this new Academy redounds to the praise of Philadelphia, yet it will always be considered one of the most glorious epochs of our century.

Another sympathetic contemporary token of appreciation for the accomplishment of the American Philosophical Society is registered in the Venetian *Giornale d'Italia spettante alla scienza naturale, e principalmente all'agricoltura, alle arti, ed al commercio:*

> This Society which has been instituted in the New World *for promoting useful knowledge* shows exactly how rapidly the inclination for this knowledge is increasing in a century in which the voices of all the friends of humanity have concurred to give it the name of "philosophic" and "illuminated."
>
> All the articles of this first volume are interesting and give the most favorable idea of the zeal of men intent upon diffusing knowledge in a region where but a short time previously there was no idea of science. . . .[13]

Nor was the admiration of the Italians limited to words; for in 1775 two of the essays in the first volume of *Transactions* were translated in the extremely widely disseminated *Scelta di opuscoli interessanti* published at Milan under the prominent editorship of the savant, Carlo Amoretti, and the educator and polygraph, Francesco Soave: namely, John Morgan's "An Essay on the Expressing of Oil from Sun-Flower Seed," and Hugh Williamson's "An Attempt to Account for the Change of Climate, Which Has Been Observed in the Middle Colonies in North America."[14]

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[10] Mazzei's communication above is reproduced from the original still in the archives of the American Philosophical Society. Felice Fontana's letter on behalf of the Grand Duke of Tuscany and the Florentine Accademia del Cimento, in Latin, is likewise in the possession of the American Philosophical Society and is published in the appendix to this article. The letters from Bologna and Turin, in Italian, survive only in the imperfect transcriptions and translations of the Minutes, but will also be found in the appendix: they are historically significant documents, and interesting as the earliest attestation to what has consistently been one of the greatest obstacles to thoroughly effective collaboration between American and Italian science, namely, difference of tongue.

It is perhaps not gratuitous to remark that the names attached to these letters are outstanding ones in the annals of Italian science. Sebastiano Canterzani (1734–1819), the secretary of the Academy of Bologna, is remembered today for his contributions to the field of mathematics. Giuseppe Angelo conte di Saluzzo di Menusiglio (1734–1810), founder and president of the famous Academy of Turin, was an able physicist, chemist, and mathematician. Felice Fontana (1730–1803) was eventually made a member of the American Philosophical Society and is treated below.

[11] Ser. 2, III: 109–111.

[12] IX: 307–308.

[13] IX: 383, 1773.

[14] II: 77–118, and IV: 3–23, respectively.

The first bright promise of intellectual fraternity and exchange was, unfortunately, blighted by the Revolutionary War, which absorbed most of the energies of the American Philosophical Society and otherwise rendered impracticable correspondence with Italy. The Italians foresaw the interruption in the remarkable progress of American science and sorrowfully resigned themselves to the loss, as appears from the following wistful introduction to an instalment of the Articles of Confederation in the March 1 issue for the year 1777 (vol. 9 : p. 130) of the Florentine gazette, *Le Notizie del Mondo:*

> One can, along with a great philosopher of our times (M. d'Alembert), rightly consider the present century as one of the most fertile in literary, moral and political revolutions. While Europe rests, so to speak, on its laurels, there arises in the New World a new nation, which at its birth, not content to afford the most unexpected spectacle of courage, prudence and patriotic spirit, applies itself, by a phenomenon marvelous and unique of its kind, in spreading culture and expanding the useful sciences, and in increasing the body of physical knowledge without becoming lost in useless objects of sterile curiosity and idle pleasure. One might say that letters are passing from Europe to establish a new residence in the remote regions of America. It suffices to cast a glance upon the institution of the Academy of Philadelphia, and upon the interesting observations which even at birth it offers us in its *Philosophical Transactions*. . . . Hence one can form a sure opinion of the literary spirit of that American nation, and of the rapid progress it is making, and it is highly to be desired that such progress be not too long interrupted, and much less destroyed, by the war which at present rages in that country; although, to tell the truth, the measures that Great Britain is adopting, and, on the other hand, the steps taken by her colonies, do not seem to announce a very near reconciliation. . . .

The almost complete absence of Minutes for the period 1776–1800 is an index to the state of the American Philosophical Society during those trying days and adequate proof that the worst fears of the Italians were all but realized. We are not even surprised to learn from one of the rare sets of Minutes of this period, those of 16 April 1779, that after the lapse of more than five years the books brought to America by Mazzei on behalf to the Academy of Turin were still in Richmond.[15]

With the successful termination of the war came the full bloom of the Franklinian era of the American Philosophical Society, the most interesting and fruitful in its history from the standpoint of relations with Italy. All Europe turned its eyes westward to speculate upon the contemporary state and future development of the new nation that had miraculously arisen in the name of freedom. Franklin, believed by most Europeans to be the single-handed architect of the American Revolution, enjoyed a prestige such as has rarely fallen to the lot of mortal man, and to no other American. John Adams' wry-faced acknowledgment of Franklin's great contemporary fame is well known and bears the stamp of essential truthfulness: "Franklin's reputation was more universal than that of Leibnitz or Newton, Frederick or Voltaire; and his character more beloved and esteemed than any or all of them."[16] It was inevitable that Franklin should be the object—often the victim—of innumerable attentions; and Italians contributed at least their share to the honors and assiduities heaped upon him. Many distinguished Italian men of letters and science crossed Franklin's threshold at Passy, and his correspondence contains numerous tangible indications of the veneration in which Italy held him. He was made in rapid succession an honorary member of the academies at Padua and Turin, of the Società italiana of Verona, and of the Società patriotica of Milan.[17] For a number of years the history of the relations of the American Philosophical Society with Italy is in effect little

[15] A passage in a letter from Franklin to Mazzei written from Philadelphia sometime during the latter part of 1776 affords interesting commentary and serves to absolve Mazzei of the charge of remissness in his mission: "I know not how it has happened, that you have not received an answer from the secretary of our society. I suppose they must have written, and that it miscarried. If you have not yet sent the books, which the Academy of Turin have done us the honour to present us with, we must, I fear wait more quiet times . . ." (*The writings of Benjamin Franklin*, ed. A. H. Smyth, VI: 455, New York, Macmillan, 1906).

Although Mazzei, by his letter cited above, bound himself to act as the Italian agent for the American Philosophical Society, there seems to be no evidence that he ever served in that capacity apart from the instance reported in his one and only extant communication to the Society.

[16] *The works of John Adams*, ed. C. F. Adams, I: 660, Boston, 1850.

[17] A memorandum by William Temple Franklin in the Congressional Library entitled "List of colleges & societys of which D.r Franklin was a member" (*cf.* Ford, W. C., *List of the Benjamin Franklin papers in the Library of Congress*, 218, Washington, Govt. print. office, 1905) includes the "[Society at] Bologna." It has been thus far impossible to verify this note of William Temple Franklin.

more than a chapter in the history of Benjamin Franklin's influence in Italy.

The first sign of quickening contacts with Italy is the donation to the Society on 3 January 1783 of four works by Felice Fontana, transmitted by Thomas Jefferson on behalf of the author.[18] On the eighteenth of the same month Fontana was elected to membership, and the event is noted in the Minutes with the unprecedented parenthetical comment, "Unanimously." This versatile naturalist, particularly active in the fields of physiology and botany, president of the recently revived Accademia del Cimento, and famed in his time for the magnificent Cabinet of Natural History which he assembled for his royal patron, the Grand Duke of Tuscany, had long been known to Franklin for a treatise on a disease of the wheat,[19] and in 1779 a personal acquaintance had been established.[20] It is, therefore, not beyond the realm of possibility that his election was at Franklin's behest.

The few records which exist indicate that Fontana was active in his desire to collaborate with scientific America. In addition to the first gift mentioned in Mazzei's letter of 1773 quoted above, and the works presented in January 1783, another bundle of four pamphlets was delivered to the Society in the name of Fontana in October 1783; whereupon the secretaries were ordered to note the last donation in the Minutes, and "in y^{e} first publication mention y^{e} presents received for some time past and particularly those from y^{e} Abbé de Fontana." Nor was Fontana's activity limited to simple transmission of his published works. A letter dated Philadelphia, 26 August 1783, from G. W. Logan to the remarkable self-taught naturalist and early member of the American Philosophical Society, Humphry Marshall, incorporates the translation of a communication from Fontana, apparently in French, to Marshall, which the latter seems to have asked his friend to render into English, wherein Fontana requests by barter or sale natural specimens from America, at the same time inviting exchange on the part of the American Philosophical Society.[21]

The last available evidence of Fontana's trans-Atlantic interests is a note in rather lame English, dated Pisa, 16 January 1784,[22] acknowledging receipt of letters, and two boxes of American plants, almost all alive, which he hoped to acclimatize; and informing that, although at the moment he was incapable of sending anything but a few seeds, more material would follow.[23]

For the next clue to information of value for this study, we must skip to the Minutes of 21 July 1786, there to be apprised that on that day a new Italian member had been elected, "Count de Castilione K^{t} of the Order of S^{t} Stephen, Milan; Now in Phil^{a}"

Surprisingly little is known of Luigi Castiglioni.[24] It is perhaps not astounding that his work as a naturalist should have been forgotten, but it is puzzling indeed that his role as one of the most successful interpreters of the New World to the Old should have received so little attention. Consequently, he well merits an introduction as complete as available information will permit.

Born in Milan in 1756 of an old patrician family which had long supplied Italy with more than its share of men of science, letters, and statecraft, Luigi Castiglioni seems to have manifested an early predilection for botany which he subsequently studied at the University of Pavia under the celebrated Giovanni Scopoli. In 1784 he left his native country on a tour that took him through France and England, and which eventually brought him to America. In Paris a letter of introduction from the great mathematician and physicist, and fellow Milanese, Paolo Frisi, admitted him to the presence of Benjamin Franklin,[25] who was obviously well enough impressed with the character and ability of the

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[18] Minutes.

[19] See letter to Ingenhousz, dated London, 30 September 1773, in *The writings of Benjamin Franklin*, ed. Smyth, VI: 141, 1906.

[20] Hays, I. Minis, ed., *Calendar of the papers of Benjamin Franklin in the Library of the American Philosophical Society*, IV: 423, Amer. Philos. Soc., 1908.

[21] First published in Darlington, William, *Memorials of John Bartram and Humphry Marshall*, 550–552, Philadelphia, 1849; republished in the appendix to this paper (no. 4). The original of Logan's letter is in the possession of the Historical Society of Pennsylvania.

[22] Darlington, *ibid.*, 552; also republished herewith (appendix, no. 5).

[23] A perusal of the correspondence of this indefatigable investigator (see Mazzatinti, G., and others, *Inventari dei manoscritti delle biblioteche d'Italia*, Forlì, 1890 ff., *passim*) and of the eighty (!) MS. volumes of his unpublished works in the Biblioteca Nazionale Centrale of Florence (Natali, G., *Il Settecento*, 210, Milan, Vallardi, 1929) would probably yield much interesting information.

[24] The bibliography of Castiglioni is all but non-existent (*cf.* Natali, *ibid.*, 252): the scant account of Ticozzi, *op. cit.*, 608, seems to be the only biography of this interesting personage.

[25] Hays, *op. cit.* III: 192: item no. 7 of appendix to the present article.

inquisitive young traveler, and with the genuiness of his mission to America, not to place obstacles in his way. In England, Castiglioni called upon the famous botanist, Jonathan Stokes, who, after the one visit, did not hesitate to recommend him as a "botanist of sound principles."[26] The distinguished English naturalist and president of the Royal Society, Sir Joseph Banks, provides further interesting details in a letter to Franklin:[27]

> . . . Count Castiglioni I have seen; he appears a well bred & well informed young man. He is at present in the Country laboring to acquire the English language which I hear his Countrymen find very difficult.

Particularly noteworthy is Castiglioni's attention to the English language—a detail whose importance was too often unappreciated by the early travelers in America.

Embarking from England late in the spring of 1785, Castiglioni arrived in Boston on 17 May, and spent the next two years in a systematic voyage of observation that carried him through each of the colonies and a part of Canada. The book which he wrote upon his return to Italy, *Viaggio negli Stati Uniti dell'America Settentrionale fatto negli anni 1785, 1786, e 1787 . . . con alcune osservazioni sui vegetabili più utili di quel paese* (Milano 1790), is the chief source of information regarding his travels, and his claim to an honorable place among those writers who have sought to make America intelligible to Europeans. His two-fold motive in coming to America can be no better expressed than in the words employed by the author himself in his two opening paragraphs:

> The revolution accomplished in these last years in North America is one of the most memorable events of this century, and may in time produce important consequences in regard to Europe. It is therefore no wonder if after such an epoch accounts of things relating to the United States are more sought after than they were before, and if various travelers have visited this country formerly little frequented by them. Among these, I too was moved by curiosity to behold the political birth of a Republic composed of diverse nationalities, spread out over vast provinces far removed from one another, and differing in climate and products.
>
> Nor was this the only motive, for an object of more immediate utility played a part in my determination: Experience having made it known that the vegetables of North America from Florida to Canada hold up very well in the climate of Europe, I considered that it might be of some advantage to travel over that country, not only to make an abundant collection of seeds, but to investigate the nature of the most useful plants, the means of cultivating and propagating them, and the uses which are made, or can be made, of them.

The work is accordingly divided into two parts, the whole of the first volume and most of the second consisting of Castiglioni's observations on colonial civilization, while the results of his collateral botanical studies are wisely segregated in an appendix to the second volume. The first part is of great and abiding interest,[28] for through the eyes of the keen young observer, the reader catches fascinating glimpses of colonial life in the various states, accompanied by sober comments upon the political institutions, industries, population, principal cities, education, manners, Indians and their relations with the whites, etc. The particularized account state by state leads to a climactic *Degli Stati Uniti in Generale* (chap. 28), in the first part of which, entitled "Del Nuovo Governo Federativo," Castiglioni renders into Italian the whole of the Federal Constitution of 1787, the second part, "Riflessioni sullo stato attuale della Repubblica Americana," being essentially a rebuttal of the notorious thesis propounded by such European writers as Buffon, Paw, and Raynal, that all manifestations of life in America are infected with the seed of degeneracy. The work ends with a well-balanced appreciation of what the Americans had gained by their Revolution in answer to those who had begun to wonder whether independence was worth its price in political, social, and economic disorder, and with a prophecy of the inevitable and rapid development of the new nation.

The book is enlivened throughout by the constant, albeit never inopportune, presence of the author, and by his frequent contacts with distinguished personalities of the period—by far the greater number of whom either were at the time, or were soon to be, members of the Ameri-

[26] Cutler, Manasseh, *Life, journals and correspondence* II: 260, Cincinnati, 1888.

[27] Dated 19 November 1784, Soho Square. In the American Philosophical Society collection.

[28] Which is not to say that the botanical appendix is entirely devoid of value—historically, at least: F. Harper, for example, in his edition of John Bartram's diary of a journey through the Carolinas, Georgia, and Florida . . . (*Trans. Amer. Philos. Soc.* **33**(1), 1942), found it of considerable service in interpreting various Bartramian species (p. 6).

can Philosophical Society. The first of these is the Rev. Manasseh Cutler, to whom Castiglioni was referred soon after disembarking[29] as better qualified than anyone else in America to give him the botanical information he sought. Castiglioni's delight knew no bounds at finding so soon after his arrival in America a person intelligently interested in the study of plants.[30] Nor was the gain at this, their first and last personal encounter, on one side only, as Cutler's references to Castiglioni in his *Journal* under the dates 23 and 24 June 1785 amply testify: " . . . He is an accomplished botanist. . . . Received much advantage from his knowledge."

The following passage from a letter written by Cutler to Jeremy Belknap a few days after Castiglioni's visit is cited as testimony to the contagious atmosphere of enthusiasm which Castiglioni must have had about him, and because it throws light upon other factors that contribute to explain his unusual success as a traveler in colonial America:

> . . . I feel anxious to make another attempt for measuring the White Mountains, but find so many difficulties in the way that I have given up the thought of going this year. The thought, however, has been a little revived within a few days, occasioned by the Count Castiglioni, an Italian gentleman from Milan, who is on his tour through the United States, principally with a view of examining their natural productions. He is very desirous of a tour to the White Mountains, and would make us a most valuable as well as a very agreeable companion. He has done me the honor of spending a day or two with me. He is a perfect master of Botany, and is preserving specimens of every vegetable in blossom. His manners are easy, affable, and engaging. He speaks English well—am told he is possessed of an immense fortune. He is now gone to Portsmouth. . . .[31]

On Christmas day of 1785 Castiglioni was at Mount Vernon, having meanwhile visited Massachusetts, New Hampshire, Vermont, Canada, New York, and being at the time engaged in rapid passage southward to Georgia, whence he planned to move north in a more leisurely manner. The fruit of his four days' sojourn at Mount Vernon is a remarkable literary portrait of his host, one of the most distinguished members of the American Philosophical Society:

> General Washington is about 57 years old, tall in stature, of robust build and a majestic and pleasing appearance, and although hardened in military service, he does not yet seem to be advanced in age. This illustrious man, who opened and brought to a happy end the American war, seemed brought forth by nature to free America from European domination and to form an epoch in the history of human revolutions. . . . The war at length gloriously terminated, acclaimed as the liberator of his country, although he saw himself adored by his troops, respected by the people, and protected by a great army, he presented himself before the Congress, gave up his command, and withdrew to his home to live a private life. This act, which crowns the glorious deeds of his laborious life, shows that the race of those men who were capable of uniting the broadest wisdom to an intrepid courage, and of conserving the most rigid virtue at the summit of power, has not come to an end in this world. After his retirement, he passed his time not indeed in idle repose, but useful to his country in peace, as in war, having laid the foundations of a new Republic, he employed his talent in the means of causing it to flourish. Applying himself to agriculture, and presiding over a large number of Negroes, who under his direction are scarcely aware of being slaves, he reduced his fields to the most advantageous state, without multiplying wine and silk which demand too costly a cultivation in a country scarse in tillers of the soil. Despite his having been raised to the profession of arms, he has not neglected the study of politics, and although he has refused offices which were offered him in the new Legislature, there is perhaps no one in America better acquainted with the present situation of the United States and who more righteously desires their prosperity. Heaven will that, living for many years, he may long serve as an example of virtue and industry to his fellow citizens, just as he served as an example to Europe in the victories which consecrated his name to an eternal fame![32]

[29] Cutler, *op. cit.*, I: 115.

[30] *Viaggio* I: 40.

[31] Cutler, *op. cit.* II: 232. Relations between Castiglioni and Manasseh Cutler do not end here: In a letter to Castiglioni, dated Ipswich, 5 December 1792, Cutler (*ibid.* II: 261) informs that he had procured membership for him in the new Academy of Arts and Sciences of Boston early in 1786, that he was personally forwarding the diploma which through some oversight had remained in America. He goes on to invite correspondence on behalf of the Academy, expresses the hope that Castiglioni will some day publish the results of his voyage to America (unaware that the *Viaggio* had appeared two years before), asks advice regarding the classification of an enclosed plant, and requests personal correspondence.

[32] *The Diaries of George Washington*, ed. J. C. Fitzpatrick, 4 v., Boston-New York, Houghton Mifflin, 1925, bear brief allusions to the arrival of Castiglioni on the twenty-fifth and to his departure on the twenty-ninth. Probably the large number of guests (which Castiglioni mentions) and the festivities attendant upon the season interfered with the establishment of any real personal acquaintance. That some exchange took place, however, is apparent, for

The summer of 1786 found Castiglioni back in Philadelphia for a protracted stay, and all signs indicate that he came to know intimately many of the resident members of the American Philosophical Society. He was able to renew acquaintance with Benjamin Franklin, who had meantime returned from France, and a letter to Benjamin Rush written from Milan on 4 February 1793[33] asking him to transmit his compliments to all their mutual friends in the Society, and "particulièrment (*sic*) à l'estimable famille de M.r Franklin," is testimony that his association with Franklin must have been more than a casual one. Castiglioni's fine portrait of Franklin, several pages in length,[34] mentions him as the founder of the American Philosophical Society, recalls his importance as a scientist, presents a brief biography up to the final return from Europe, gives a short but effective account of his role in the stormy revision of the Constitution of Pennsylvania, and ends by extolling him as a living example of that rara avis, a philosopher who lives in accordance with his own precepts. No clearer proof could exist of the esteem in which Franklin, on his part, held Castiglioni, than his act of addressing to him on 14 October 1878 a copy of the freshly redacted Federal Constitution, on the very day that he similarly honored the Duc de la Rochefoucauld d'Anville and Gaetano Filangieri.[35]

After Franklin, Benjamin Rush seems to have been Castiglioni's most congenial American friend. In 1786 Rush and Franklin were contemporaneously elected corresponding members of the Società Patriotica of Milan, probably at the instance of Castiglioni.[36] In 1792, after Franklin's death, Castiglioni chose to transmit the copy of his *Viaggio* destined for the American Philosophical Society through the hands of Rush, sending along at the same time a copy for his friend,[37] and a cordial exchange of material took place in 1793.[38]

Scattered evidence remains as to the nature of Castiglioni's friendships with other members of the American Philosophical Society. Ezra Stiles, President of Yale College, records in his diary with sensible pleasure a visit from "the ingenious young Count Castaglioni" on 29 August 1786.[39] A visit to the Virginian botanist, James Greenway, elicited much useful information, some of which Castiglioni used in the botanical part of his *Viaggio*.[40] He also acknowledges personal aid in his botanical observations from the geographer, Thomas Hutchins.[41] With Dr. John Foulke, he collaborated in a study of that enigmatical creature, the opossum[42] In view of the similarity of interests, it is almost inevitable that he came to know Humphry Marshall, whom he cites repeatedly in his botanical appendix, and the Bartrams, whose famous garden he mentions.[43]

A glowing tribute to the American Philosophical Society as a body is inherent in Castiglioni's confutation mentioned above of the theory spawned by Buffon of the degeneracy of men and animals in the New World; for whom could Castiglioni possibly adduce to refute a statement of Raynal that the New World had not yet produced a good poet, a clever mathematician, a man of genius in a single art, or in a single science, but predominantly his fellow members of the American Philosophical Society?—beginning ap-

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on 27 January 1786 Washington wrote a brief introductory letter in Castiglioni's behalf to Governor William Moultrie of South Carolina (*The writings of George Washington*, ed. J. C. Fitzpatrick, XXVIII: 44, note, U. S. Govt. print. office, 1938).

In a footnote to the entries in Washington's *Diaries* that register the presence of Castiglioni, Fitzpatrick dismisses the latter's mention of the visit to Mount Vernon as "merely incidental and of no value." Corrections are in order: It is clear to anyone who has read the whole *Viaggio* that Castiglioni meant to highlight the personalities of Washington and Franklin, whom he obviously regarded as the two most outstanding Americans, and accordingly penned coherent portraits of them, no other Americans being so honored in his book. Castiglioni's sketch of Washington certainly compares with the best in Baker, W. S., *Character portraits of Washington*, Philadelphia, 1887.

As for the incident's being "of no value," that may be so from the standpoint of documentary American history. Its human value as a sincere tribute to Washington, and its possible inspirational value for the Italians of the Napoleonic era and Risorgimento are quite another matter.

[33] In the Library Company of Philadelphia, Broad and Christian Streets, now called the Ridgway Branch of the Free Library of Philadelphia.

[34] *Viaggio* II: 38–41.

[35] See Ford, W. C., *Op. cit.*, 185. Castiglioni was doubtless working from this copy presented to him by Franklin when he made the translation which he incorporated into the *Viaggio*.

[36] Carlo Amoretti to Rush, in the Library Company of Philadelphia; published in appendix (no. 8).

[37] Letter, Castiglioni to Rush, in the Library Company of Philadelphia.

[38] Letter cited in note 33 above.

[39] *The literary diary of Ezra Stiles* (ed. F. B. Dexter), III: 236, New York, Scribner's, 1901.

[40] II: 333.

[41] II: 375.

[42] II: 74.

[43] II: 163, note.

propriately with Washington and Franklin; continuing with others who had likewise distinguished themselves in both war and the peaceful arts—Henry Knox, John Adams, John Jay, James Madison, Thomas Jefferson; then the mathematicians—Samuel Williams, Joseph Willard, David Rittenhouse; in medicine—Benjamin Rush; students of natural history—the Bartrams, Humphry Marshall, Manasseh Cutler, James Greenway; historians—Jeremy Belknap and David Ramsay; in literature and the fine arts—Francis Hopkinson, Joel Barlow, John Trumbull, Benjamin West. Indeed an imposing array of names, calculated to discredit forever Buffon and his cohorts![44]

It appears to have been Castiglioni's original intention to leave for Europe toward the end of the year 1786,[45] but for some reason he postponed his departure until the following spring. He spent the winter partly in New York, partly in Philadelphia, and the Minutes of the American Philosophical Society show that he attended the meetings of 15 December 1786 and 2 March 1787. Taking a Spanish boat from New York on 16 May 1787, almost exactly two years after his arrival in Boston, he reentered Europe through Spain.

For Castiglioni's life after his return to Italy, we must again resort to Ticozzi, who tells us that he brought back many unknown seeds and plants, one in particular, the locust (robinia), lending itself so readily to acclimatization that in the year in which the biographical memoir was being written (1832 or 1833), it flourished in all Lombardy.[46] After the publication of his *Viaggio*, Castiglioni turned to the translation of Latin agrarian writers, and the study of numismatics, making a remarkable collection of Lombardic coins which he subsequently donated to the Ambrosian Library in Milan. Such public-spirited behavior, conjoined with a policy of sympathy and generosity toward his tenants, appears to have acquired for him a widespread reputation as a philanthropist. Many political and academic honors were accorded him before his death in 1832. He was made a member of the electoral college of land-holders, of the money commission, of the Napoleonic Italian Institute; before 1796 he was chosen director of the municipal botanical garden of Milan, and, 1807, of the royal printing house; he became President of the Academy of Fine Arts of Milan, a Senator of the Kingdom of Italy, a Knight of the Iron Cross.

In sum, enough information is available to justify the assumption that Castiglioni enjoyed great prestige among his compatriots in one of the most enlightened regions of Italy, and therefore that his reading public must have been extensive in number and range. Hence, many of those parts of the *Viaggio* which the American reader will pass over as commonplace cannot be lightly dismissed. The role, for example, that Castiglioni's translation of the Constitution played in shaping the trend of events leading to the Risorgimento is yet to be evaluated; but we can meanwhile rest assured that it was more than a momentary whim that moved the wily Franklin to send a copy of that monumental document to Castiglioni. The greater part of the *Viaggio*, with its abundance of picturesque detail and acute observation, is at least as interesting for the Americans of today as it must have been for Castiglioni's Italian contemporaries. One aspect of the book deserves to be noted—the fact that much of the political commentary is, in a sense, written by Americans; for it is apparent that in his desire to avoid the misinterpretations and distortions that have only too often vitiated the accounts of other early observers in America, Castiglioni frequently resorted to the counsel of his American friends, many of whom had played essential roles in state and national politics.[47]

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[44] The point of departure for this passage in the *Viaggio* is obviously furnished by Jefferson's *Notes on Virginia* (see *The writings of Thomas Jefferson*, ed. A. E. Bergh and A. A. Lipscomb, I: 155, Washington, Thomas Jefferson Mem. Assoc., 1904), of which work Castiglioni takes due note in his book (II: 155).

Castiglioni seems to be the sole authority for an interesting bit of information relative to the early history of the Society, which, for want of a better place, is reported here: "To the right [of the Town Hall]," he says at one point in his description of the city of Philadelphia, "there is being constructed a three story house for the use of the Philosophic Society, and in the basement it is intended to set up the Chemical Laboratory."

[45] Cutler, *op. cit.* II: 247.

[46] The *Grande Enciclopedia popolare Sonzogno* also attributes to Castiglioni the introduction of two other plants, the catalpa and the arbor vitae (le tuie).

[47] A signal example is the precious letter of the Attorney General of Pennsylvania, William Bradford, to Castiglioni (*Viaggio*, II: 23, note), which acknowledges outright the debt of the penal system of his state to the great Italian criminologist, Cesare Beccaria. This letter is reprinted in English translation in Schiavo, G., *The Italians in America before the Civil War*, 31–32, New York-Chicago, Vigo Press, 1934.

Obviously a work of such high interest and value as Castiglioni's *Viaggio* should be more accessible to American

While Castiglioni was still in America, the second volume of *Transactions* had been printed (1786), and the Minutes of 21 July 1786 inform that it was "On Motion agreed that Dr Franklin, Saml Vaughan & Francis Hopkinson Esqres be a committee to forward the Sales of the Volume of Transactions lately published, and to send in donations, any number not exceeding twenty copies, to such Societies and particular persons in Europe as they shall think entitled to this respect." That Italy was not overlooked by the committee can be deduced from the amazing fact that before the year was out three of the essays contained in the new volume of *Transactions* had been translated into Italian![48]

Continuing to read in the Minutes, we learn that on 19 October 1787, "A letter was received, & read, dated Turin le 8 Fevrier, from M. le Comte Morozza Cassitane, Major du Regiment aux Gardes, Membre dela Societé Italiena—." This letter, still in the archives of the American Philosophical Society,[49] marks the revival, after the interruption of the Revolutionary War, of a tenacious exchange between the two institutions that has continued to the present day.

The Minutes of 15 August 1788 reveal that the case of material sent from Milan by Carlo Amoretti, the Secretary of the Società Patriotica, more than two years before, consequent upon Castiglioni's hint that the American Philosophical Society would welcome exchanges,[50] had just come to hand, the delay probably occasioned, as Amoretti suggested in a second letter,[51] by the obliteration of the address. The delivery of the precious box, containing along with other material Amoretti's first letter to Rush, possibly the letter of 15 May 1786 to Franklin,[52] diplomas of corresponding membership in the Società Patriotica for both Franklin and Rush, the first volume of transactions of the Società Patriotica and the first two of the Società italiana of Verona, donations of books for the American Philosophical Society from the physiologists, Lazzaro Spallanzani and Bassiano Carminati, and from the botanist, Giovanni Scopoli, a personal gift of minerals from Ermenegildo Pini to Mr. [Samuel?] Vaughan—evoked solicitous efforts on the part of the American Philosophical Society to remedy their apparent lack of appreciation by ordering the Secretaries to send an immediate letter of explanation, accompanied by a copy of the new volume of *Transactions*.

The extant documents indicate a steady intercourse between Italy and the American Philosophical Society during the last decade of the eighteenth century. In 1791 the fourth volume of *Memoirs* of the Academy of Turin arrived: on 15 May 1795 the fifth volume (for the years 1790–1791) "in sheets through the hands of Dr Rush—whereupon it was "Ordered that Mr Bleakley, one of the Secretaries, be directed to acknowledge the receipt of the above donation, and transmit to that Society the 3d vol. of our Transactions." On 20 January 1792 the Society admitted to membership Count Paolo Andreani who eight years before had achieved celebrity as the first Italian to construct and ascend in a balloon, and at the time of his election was engaged in a tour of America.[53] At the same meeting was elected the ill-starred sculptor, Giuseppe Ceracchi, doomed to die in Paris by the guillotine in 1801 under accusation of complicity in a plot to assassinate Napoleon. Ceracchi had come to this country in 1789, despite earlier disuasion by Franklin,[54] with the

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readers than it is at present—its rarity and language being generally insurmountable barriers; I have, accordingly, engaged in preparing an edition in English translation.

[48] Vol. 9 (1786) of the *Opuscoli scelti sulle scienze*, successor after 1777 to the *Scelta di opuscoli interessanti*, but under the same alert editorship (see note 13 above), offered its readers in native idiom "A letter from Dr. B. Franklin, to Dr. Ingenhausz, Physician to the Emperor, at Vienna, on the causes and cure of smokey chimneys," "An account of some experiments on magnetism, in a letter to John Page, Esq., at Williamsburg, from Mr. Rittenhouse," and Francis Hopkinson's "Account of a worm in a horse's eye."

Vol. 10 (1787) of the same collection contained further translations from the same source: "A letter from the Rev. Jeremy Belknap, on the preserving of parsnips by drying," Franklin's "Description of a new stove for burning of pit-coal, and consuming all its smoke," as well as the "Letter to Mr. Nairne, of London, from Dr. Franklin, proposing a slowly sensible hygrometer for certain purposes."

In vol. 15 (1792) of the *Opuscoli scelti* is found a sarcastic rebuttal by the famous Italian savant, Gian Rinaldo Carli, of "A letter from Mr. Otto to Dr. Franklin, with a memoir on the discovery of America," which had been published in vol. 2 of the *Transactions* of the American Philosophical Society, and wherein Columbus had been summarily deprived of the honor of having discovered America.

[49] See appendix, no. 10.

[50] See appendix, no. 8.

[51] To Benjamin Rush, Milan, 29 March 1788; in the Library Company of Philadelphia.

[52] Appendix, no. 9.

[53] For an excellent account of what is known of Andreani's activity in this country, see Smith, G. Hubert, Count Andreani: A forgotten traveler, in *Minnesota History* 19: 34–42, 1938.

[54] *The writings of Benjamin Franklin*, ed. A. H. Smyth, IX: 44–45, 1906.

hope of obtaining an assignment to erect a grandiose monument in commemoration of the American Revolution, and was eventually obliged to return to Europe disappointed in his aspirations, even as Franklin had prophesied; but not before having made busts of Franklin, Hamilton, Washington, and Rittenhouse, the last work a gift to the American Philosophical Society.[55]

On 20 April 1798 the Society elected "J. B. Scandella, M.D. of Venice, now in U. S.," regarding whom our information is very meager. He appears to have been friendly with Benjamin Rush who was much impressed by his ingenuity,[56] and may have sponsored his nomination. Benjamin Henry Latrobe, remembered as the architect of the national capitol, in his *Journal*[57] undertakes to answer Scandella's query whether Virginians are truly hospitable, in the course of which disquisition one learns not only that Scandella was disappointed in the much vaunted American hospitality, but that he was "a man of letters and a theoretic farmer," ". . . a Venetian gentleman of the most amiable, fascinating manners, and of the best information upon almost every scientific subject, who speaks English perfectly, and who has now traveled through all the country between the St. Lawrence and James rivers . . ."; and that Thomas Jefferson had been one of the very few Americans to transcend the general "beef-and-mutton" hospitality and to accept with good grace Scandella's eager questions about the country and the state of society.

The century ends appropriately with an attempt on the part of the American Philosophical Society to inventory the status of its relations with foreign societies for the purpose of supplying copies of the *Transactions* wherever collections were not complete.[58] And of the twenty-seven societies scattered from Mexico to India considered in the survey, with marginal notations as to deficient volumes, five are in Italy—namely, those at Bologna, Milan, Florence, Turin, and Verona.[59]

With the turn of the nineteenth century, we may consider the Age of Benjamin Franklin closed, for the new century brings to the fore new forces and orientations on both sides of the Atlantic. As one stands upon the bridge between the two centuries facing the tempestuous new era, he may be excused a nostalgic backward glance upon the eighteenth century to marvel at what had been accomplished. The faith of the children of Enlightenment seemed to gather strength before mountains, for the degree of collaboration attained by eighteenth-century Italian and American science as reflected in the activities of the American Philosophical Society looms as a phenomenon little short of miraculous in view of the formidable obstacles that stood in the way. Even at best, communications between America and Italy were slow and unsure. Furthermore, Italy suffered from peculiar disadvantages: the interference of the Barbary pirates reduced to a trickle direct intercourse by way of the Mediterranean, and deliveries through London and Paris gave rise to additional delays and hazards. Aside from these chronic inconveniences, the American Revolution, with the attendant British blockade, created new difficulties. Moreover, the problem of difference of tongue was a sore one and only partially solved by the use of French and sometimes Latin. Yet, in the face of all handicaps, there was no faltering in the desire to share experience, with the result that the measure of cooperation achieved by the Americans and Italians in this period must be looked upon as one of the more inspiring chapters in the history of human cultural exchange.

II. SINCE 1800

Fresh admiration arises for the solidity with which our pioneers in international science built when one reflects that their work survived the European cataclysm of the last years of the eighteenth century and its violent aftermath in the first part of the nineteenth. The storm which broke in France in 1789 swept with inexorable force and fury into Italy, with great disruptive effects upon the intellectual life of that country; and the Napoleonic era which it ushered in was but little more favorable. Many of the men who had formerly been active collaborators became estranged as the result of clashing political views; some lost their lives in the hectic see-saw of political fortunes that characterized the times; others—and among the savants the percentage

[55] Minutes, 6 February 1795.

[56] Rush's MS. *Commonplace book*, July 1798, in the Library of the American Philosophical Society.

[57] Ed. J. H. B. Latrobe, 42 ff., New York, Appleton, 1905.

[58] Minutes, 18 July and 16 August 1799.

[59] It would appear, however, from the notes later subjoined by the Secretaries that the American Philosophical Society carried out its intentions only with respect to the Academy of Turin.

was unfortunately a rather large one—compromised themselves with their governments for their ready acceptance of the principle of the French Revolution. Many a promising academy of the 1770's or 80's was bowled over by the blast, never to arise again. Others, with hardier roots, revived, usually with more than a perceptible touch of protective coloration. Let us glance at the fate of the half dozen institutions which had so hopefully entered upon exchanges with the American Philosophical Society: their vicissitudes will epitomize the condition of similar organizations in Italy during the earliest and most turbulent phase of the throes that attended the birth of modern Europe. The Florentine Accademia del Cimento, presided over by Felice Fontana, expired, despite its hallowed origins; as did the more recent Società patriotica of Milan. The Academy of Bologna, becoming a pawn of Napoleon's passion for reorganization, was transformed into a national institute, and did not recover from his tender administrations until after 1829. The famous Società italiana of Verona (today the elite Società italiana delle scienze, or Società italiana dei XL), of which Franklin was made one of the twelve original foreign members at its founding in 1782, took refuge in Modena in 1796 in the midst of great political and social disorders; in the confusion the association with America seems to have been forgotten, and relations with the American Philosophical Society were not resumed until after the middle of the nineteenth century. The Academy of Turin, after a complete suspension of activities from 1792–1801, reappeared in the Napoleonic period as a national academy with vast modifications, some of which remained even after it reassumed its old name in 1815.[1]

Against this sombre canvas, some of the events of the closing years of the eighteenth century take on a new light. What a story of undimmed hope is symbolized by the dishevelled sheets representing volume 5 of the *Mémoires* of the Academy of Turin which in 1795 passed through Rush's hands to the American Philosophical Society—transmitted doubtless by some member after the official dissolution of that Academy! We wonder sadly what happened to the second volume of the *Transactions* that the American Philosophical Society sent in exchange. We are no longer surprised that the noble attempt of the American Philosophical Society in 1799 to establish on a firm foundation its relations with Italian academies came to naught.

Unprecedentedly lean years follow the turn of the century. The frequency with which Italian members have been chosen has proved to be in general a good index to the status of relations between the American Philosophical Society and Italy. And, alas, after Scandella's election in 1798, no Italian member is admitted before the historian, Carlo Botta, in 1816, this gap of eighteen years being the widest until modern times. Much of the ebb may be safely ascribed to the unsettled conditions of Europe. One cannot help observing, however, that this nadir coincides with the period during which Thomas Jefferson held the presidency of the American Philosophical Society (1797–1815). The fact may be a pure coincidence. There is, nonetheless, reason to believe that Jefferson did not go to any lengths to foster relations with Italy; for, while Jefferson's interest in that country is well known, and his correspondence with Italians quite extensive, yet his general attitude toward Italy was that of an antiquarian. This attitude of Jefferson may be a reflection of the new orientation of America, glorying in its new-found independence and strength, becoming conscious of its own past, and therefore prone to abjure Europe as a matter of pride and principle.[2] At any rate, although Jefferson elicited from Italy a full measure of admiration for himself as an individual, it is clear that for Italy, at least, he never symbolized the American Philosophical Society as had Franklin.

The first indication of intercourse between the Society and Italy in the nineteenth century does not appear until the Minutes taken at the meeting of 3 May 1805—but that clue leads to one of the most interesting episodes in the history of the collaboration of American and Italian medical science. Among the donations of which notice is taken during that meeting are two works published at Leghorn in 1804 by a Dr. Gaetano Palloni of that city: *Collezione di notificazioni e ordini per la deputazione di sanità in Livorno*, and *Osservazioni mediche sulla malattia*

[1] For the history of Italian academies in this epoch see in general Maylender, *op. cit.* (note 3, sect. 1); also the *Enciclopedia italiana* (Treccani) under "Accademie," and the names of the cities which are their seats. For the Società italiana delle scienze, see likewise E. Paterno in its *Memorie di matematica e di scienze fisiche e naturali*, 3d s., **23**: v ff., 1930.

[2] *Cf.* Brooks, Van Wyck, *The world of Washington Irving*, 146 ff., Philadelphia, Blakiston, 1944.

febbrile dominante in Livorno. The members of the American Philosophical Society, doubtless retaining vivid memories of the devastation wrought by the yellow fever in Philadelphia a few years before, were quick to sense their possible value, and Dr. Caspar Wistar and Peter S. DuPonceau were appointed a committee to examine the treatises and to report to the Society. Six months later, after begging for at least one extension of time, they laconically pronounced "the same as interesting to medical men."

Behind the scenes, however, there is an absorbing little action in which Benjamin Rush is the protagonist, as becomes apparent from his unpublished correspondence with an expatriated American clergyman and former Philadelphian, Thomas Hall,[3] who in 1784 settled in Leghorn. Rush's heroic role in the epidemic of yellow fever which raged in Philadelphia in 1793, and his subsequent writings on that subject, had broadcast his name over all Europe, and Italians had joined in the general acclaim. So when Leghorn was plagued by the same malady in 1804, Palloni understandably turned to the famous American authority for advice which Rush did not fail to provide. In 1808 Rush was made a member of the Accademia delle lettere, scienze ed arti of Leghorn, with which Palloni was connected. But the crowning distinction was the gift of a medal struck especially in his honor by order of the Queen of the Napoleonic Kingdom of Etruria; which led John Adams to remark in a whimsical postscript to a letter addressed to his dear friend:

> I forgot a principal Point I had in view when I sat down, i.e. to congratulate you that the Queen of Etruria has fallen in Love with you. Tell Mrs. Rush that I congratulate her that the Queen of Sheba is not likely to visit Solomon at Philadelphia.[4]

The temporary equilibrium reached in the closing years of Napoleon's régime is reflected in a noticeably increased volume of traffic between the American Philosophical Society and Italy. The Minutes for 19 May 1809 note a request for exchanges from the Royal Library of Milan. About 1810 the Académie impériale des sciences, littérature et beaux arts a Turin (!) begins once more to transmit its *Mémoires*. On 2 November 1810 is registered the first donation of *Annales* by the Royal Observatory at Turin, delivered through W. Russell, American Consul at Paris.

A few words on the paramount role played by Turin, with its famous academy, university, and observatory, in the establishment and maintenance of early Italo-American contacts will not be out of order at this point. Franklin's election as one of the original foreign members of the academy, and his correspondence with Giambatista Beccaria, Professor of Experimental Physics in the university, furnished the point of departure for a tradition of collaboration with America of which the Turinese were inordinately proud. When George Ticknor visited Turin in 1836, the aged Count Prospero Balbo could show him no more precious objects than the letters that Franklin had written to Beccaria, and to which he had fallen heir upon the death of his old master.[5] The establishment of a consulate in Philadelphia by the Kingdom of Sardinia served to strengthen connections and furnished a direct and dependable means of interchange. A large donation made through the hands of the Consul General, Gaspard Deabbate, on 20 December 1822 brought up to date the collection of publications of the Academy of Turin in the Library of the American Philosophical Society, and relations have never since been permitted to languish. Within the years 1816 to 1831 five Piedmontese were made members of the American Philosophical Society: Carlo Botta, author of the dramatic *Storia della guerra d'indipendenza degli Stati Uniti d'America:* Gaspard Deabbate, the Sardinian Consul General; Lorenzo Martini, physiologist and philosopher, Rector of the University of Turin, of whom we shall have occasion to say more below; Prospero Balbo, statesman, scientist, and educator; Giacinto Carena, physicist and man of letters. Of these, all but Deabbate were members of the Academy of Turin; moreover, Prospero Balbo became its President, and Carena its Secretary. The contributions to the Library of the American Philosophical Society of these and other Turinese, all outstanding in their chosen fields, constitute a constant stream during the first part of the nineteenth century. Giovanni Plana, Amedeo Avogadro, Alessandro Dorna, Luigi Colla, Angelo Sismonda, Giuseppe Gené, Luigi Bellardi, Carlo Francesco Bellingeri, Alessandro Saluzzo di Menusiglio, Giuseppe Mazzola, and others, all of them associated with the Academy, University, or Observatory, gave concrete manifestations of their interest in the

[3] In the Library Company of Philadelphia.

[4] *Old family letters*, 134, Philadelphia, 1892.

[5] Ticknor, *Life, letters, and journals*, ed. G. S. Hillard, II: 42, Boston, 1876.

society founded by Franklin on the other side of the Atlantic.

There is a subtle, but undeniable, connection between the extraordinary interest in America on the part of the Turinese as betokened by collaboration with the American Philosophical Society and the fact that Piedmont was in the vanguard of the movement which eventually led to freedom and unity for Italy. Rendered powerless to express themselves politically, particularly after the Restoration, the Italians sublimated their patriotic aspirations in literary and scientific activity: and just as Italian literary Romanticism stands apart from contemporary manifestations of the same movement in other nations by virtue of the inconspicuousness of that element of unbridled individualism that traditionally characterizes Romanticism, which in Italy was absorbed into the strong undercurrent of concerted political intent, so scientific activity of that period appears to have been to a marked extent a part of the same concerted intellectual fifth column designed to create a spirit of moral unity and confidence, which expressed itself, when the time was ripe, in the Risorgimento.

In such mood, it was only natural for the Italians, and particularly for the Turinese, to look westward across the ocean to a nation that had attained the goal to which they aspired. Passing over what is doubtless the greatest single piece of propaganda for the Risorgimento inspired by America, Botta's *Guerra dell'indipendenza degli Stati Uniti*, we come to one which, if less important and literarily inferior, is for us extremely interesting because of its direct connection with the American Philosophical Society. The book in question was published at Turin in 1832 by Lorenzo Martini, who had been made a member of the Society in 1830 after having subjected them to a deluge of his compositions, mostly on the subject of physiology, and it bears the striking title: *Philadelphic Discourses, or Annals of Italian Genius.*[6] Each "Discorso" is addressed by Martini to his fellow members of the American Philosophical Society. The opening of the "Discorso primo," being the most significant part of the work, is well worth reporting in a close translation of the author's own words:

In my most verdant years, Honored Academicians, I heard resound the names of Franklin and Washington. Their virtue inspired within me a feeling of reverence near to religion for your country. Hence I eagerly sought out everything that concerned your past, and your glories filled my soul with honest exultation. My heart took special delight in the thought that between America and Italy, and more particularly between the United States and Piedmont, there was a close and ancient alliance. A Christopher Columbus, Ligurian, discovered your continent: an Americus Vespucci, Tuscan, gave it his own name: a Giambatista Beccaria, Piedmontese, shares with the immortal Benjamin the honor of having expanded electrical science: finally, a Carlo Botta, another Piedmontese, undertook to narrate with Livian grandiloquence your brilliant, nay more, marvelous, deeds. Wherefore my affection for you constantly increased, but remained enclosed within my breast. When my August King and Master called me to instruct Subalpine youth in the science of the physical man, I believed it my duty to compose a treatise to smooth the way. It was then that I dared offer you my writing and manifest my devotion. I did not doubt at all that you would receive it benignly; for indulgence is proper to true wisdom: but my aspirations did not extend any further. You voluntarily climaxed your favor by adorning me with the most honorable title of fellow member. And your act of election aroused in me a lively desire to make to you a public testimony of my gratitude. The first thought that occurred to my mind was that of expounding the history of the wisdom of the Italians, beginning from the most remote age, and proceeding step by step to the one in which we live. In such wise, it seemed to me that I should be discharging two duties at the same time. I have always believed that every mortal, but especially those who cultivate the ingenuous disciplines, ought in the course of his life so employ himself as to leave to posterity some monument to his love for his native land. I therefore intended to erect one according to my capabilities. Furthermore, by revealing the merits of Italy to the good Americans who accept my poor things with such an overabundance of courtesy, I was fulfilling another duty of mine. But time flees with great rapidity, and death comes close behind by leaps and bounds. Wherefore, not trusting much in life, I contemplated beginning straightway to present you a sketch of the picture which I had conceived in my mind. Nor shall I desist from my original intent, however: which if it be not granted me to carry to conclusion, at least I shall strive to amend the lack of time by assiduous labor. Cicero took the title of his discussions from Tusculum, where he composed them: and I shall give to these discourses of mine the name "Philadelphic," because while I pen them, I circulate among you and speak to you.

[6] *Discorsi filadelfici ossia Fasti del genio italiano.* The American Philosophical Society possesses a copy donated by the author.

The "Discorsi" that follow are a potpourri of mythology, geography, ethnology, political, literary, and scientific history, culminating in a half dozen chapters on the development of physiological studies in Italy which alone can claim a modicum of coherence and for which the antecedent material purports to be a preparation. Unity is provided only by the intense spirit of national pride that permeates the work, and by the sustained apostrophe which keeps the American Philosophical Society present as the audience while Martini proceeds with his informal conversations. The book is withal very readable, and its effect among the Piedmontese must have been considerable, particularly in view of the author's influential position as a scientist, philosopher, and educator.

The role played by the American Philosophical Society in Martini's *Discorsi filadelfici* is not surprising in the light of the reputation which the Society enjoyed in Italy because of its distinguished membership, scientific achievement, and record of sympathetic international collaboration. When interpreted from the standpoint of the motives which prompted its creation, the work is a noteworthy addition to the literature attesting to the fascination that republican America held for freedom-hungry Italians.

A conspicuous instance in which the American Philosophical Society served as a well of inspiration for actual political activity appears in its relations with Charles Lucien Bonaparte. This brilliant scion of the Bonaparte family had followed to America his uncle, Joseph, whose daughter he had married. The American Philosophical Society was not long in recognizing the value of his contribution to natural science by admitting him to membership in 1824, and the Minutes, Donation Books, as well as scattered letters, show that after his return to Europe Bonaparte did not allow the intervening ocean to sever him from his former American associations.

Much of the material in the available correspondence and in the Minutes of the American Philosophical Society relating to Charles Lucien Bonaparte after his return to Europe has to do with the activities of a certain yearly Congresso degli scienziati italiani which first assembled at Pisa in 1839, and for the tenth and final time before the achievement of national independence at Venice in 1847. The probable instigator and an untiring promoter of these gatherings, Bonaparte regularly informed the American Philosophical Society of the time and place of each successive meeting, begging for any support that the Society could afford, which seems quite consistently to have been extended to him at least in the form of his appointment as their delegate. While the role of these Congressi in encouraging scientific activity and in disseminating scientific information is not to be minimized, they are remembered today especially for their political import; for they were the first concrete expression of Italian national unity.[7] The reactionary authorities were quick to sense their mistake in permitting the first meeting, and subsequently did everything in their power to interfere, efforts to that end ranging from prohibitions against attending issued their subjects by certain states (notably Naples and Rome) to the desperate extremity of inviting the Congressi in the hope of thereby being able to subject them to more effective control. The second Congresso was held in Turin under the presidency of Alessandro Saluzzo di Menusiglio, the President of the Academy of Turin, and, significantly, of the same family as the Giuseppe Angelo Conte di Saluzzo di Menusiglio who had so eagerly opened relations between the Academy of Turin and the American Philosophical Society in 1773. The third meeting was at Florence, held under the auspices of the Grand Duke Leopold II, despite the violent protests and recriminations of the Austrian court, of which Tuscany was then an appanage; and it was unquestionably this liberal act on the part of the Grand Duke which prompted Bonaparte to propose him soon afterwards to membership in the American Philosophical Society.[8] Opposition increased steadily with the fourth and fifth Congressi at Padua and Lucca, respectively, and at the sixth, in Milan, Bonaparte propagandized literally at the point of the Austrian bayonet. The seventh reunion at Naples in 1845 was, despite all the watchfulness of the Bourbon police, the tocsin of the Revolution, and the names of many of the scientists present—Brofferio, Collegno, Montanelli, Salvagnoli, Pasini, Vannucci, Tazzoli—were shortly to reappear as those of leaders in the Risorgimento. The last gatherings at Genoa and Venice were in effect little more than final consultations before the outburst of the decisive conflict which ended with Italy

[7] See art. "Congressi scientifici," with bibliography, by M. Menghini, in the *Enciclopedia italiana* (Treccani).

[8] Appendix, no. 16.

at last in possession of her unity and independence. Incidentally, Bonaparte's inflammatory utterances at the last meeting caused him to be expelled from Venetian territory and banished from all regions under Austrian control.

Material of the greatest direct interest to us regarding the Congressi degli scienziati is to be found in the correspondence of Charles Lucien Bonaparte with the Secretaries of the American Philosophical Society, and with his friend and co-member in the Society, Edward Everett,[9] who went to Italy for reasons of health toward the close of the year 1840, was introduced by Bonaparte into the activity of the Congressi, and even attended one of their reunions, the third, at Florence in 1841. These letters are frequently striking in the forthrightness of their implications, but more often than not a sibylic subtlety characterizes their expression:—for example, Everett's circumspect parenthesis in "I congratulate you on your success in establishing this intellectual congress—I agree with you that it is capable of producing the most beneficial effects of counteracting (as far as the progress of improvement is concerned) the want of political centralization,"[10] written in answer to Bonaparte's more ingenuous "I have succeeded . . . in founding an Institution which will in a very short time change the face of this fair peninsula."[11] Other passages in the Bonaparte correspondence are so equivocal as to render their interpretation problematical and offer a good opportunity for anyone who wants to read between the lines. The opening lines of the "Extract of a letter from the Prince of Canino and Musignano to the Librarian [of the American Philosophical Society], dated Rome June 8, 1846" are a case in point:

> Notwithstanding my irregular *mandate*, you may have seen by our *Atti* that I lost no occasion to boast of my title of your representative; and to forward what I thought (deprived as I was of instructions) your American scientific and philosophical views. . . . If besides the American Philosophical Society, other Societies will favour me with their letters, it will give much illustration and weight to our Italian Congresso. If any American *Savant* were travelling in Italy, I should be proud to be his colleague. The meeting [the eighth in Genoa, 1846] will be grand and most interesting to Science and civilization.[12]

The *Atti* referred to by Bonaparte must be those of the congress held at Naples the preceding year, but there is nothing in that volume which corresponds to the "American scientific and philosophical views" so impressively announced by Bonaparte except a few insignificant and impromptu remarks introducing some American bibliography on the subjects of ornithology and ethnography. However, when one recalls that the reunion at Naples in 1845 was acclaimed by DeSanctis, who attended, as the "precursor of the Revolution," it may not be rash to surmise that Bonaparte was calling attention rather to the rousing words of welcome and farewell that he addressed to his Italian colleagues as President of the Section of Zoology and Comparative Anatomy. The suspicion arises that Bonaparte's insistance upon credentials from the American Philosophical Society was motivated by the realistic consideration that as delegate of the Society he could express effectively—and with comparative impunity—ideas purportedly transmitted from America. There is not much reason to fear that the absence of specific instructions from the American Philosophical Society interfered to any extent with Bonaparte's activity on that occasion.

A comparison of Bonaparte's letters and the Donation Books of the American Philosophical Society leads to an interesting conclusion. One would expect that, because of its regular connections with the various Congressi degli scienziati, the Society would have in its library the *Atti* for each year, or at least a majority of the transactions. It possesses, however, only the first and third volumes, for the years 1839 and 1841, which the Donation Books show did not come to hand until February of 1844. In his letter of 29 July 1842 to the Secretary of the American Philosophical Society,[13] Bonaparte remarks, apparently in answer to a query regarding the *Atti:* "The Transactions of the three Congress' have been published each year in succession. I am astonished you did not receive any of them"; whence it would appear that the volumes had been sent as they appeared, but had never reached their destination, the two volumes at present in the Library of the American Philosophical Society being the result of a new shipment. Furthermore, in the Extract from his letter dated Rome, 12 July 1845, to the Librarian of the Society,[14] Bonaparte says, re-

[9] For example, letters 13–20 in appendix.
[10] Appendix, no. 14.
[11] Appendix, no. 13.
[12] See appendix, no. 19, for the complete document.
[13] Appendix, no. 16.
[14] Appendix, no. 18.

ferring to the coming meeting at Naples: " . . . from the position I shall occupy in that learned body, as the Society's representative, I shall be enabled to procure for your library all the published Transactions . . ."; and his unquestionable faithfulness to the American Philosophical Society leaves no room for the suspicion that he did not attempt to keep his promise. In fact, the beginning of the Extract from his letter of 8 June 1846 to the Librarian of the Society[15] clearly implies that the *Atti* of the Congresso of 1845 at Naples had been sent, and that in his belief they might have already reached their destination. In short, one must conclude that in all likelihood the American Philosophical Society would today have on its shelves a complete set of the rare and valuable *Atti* of the Congressi degli scienziati italiani had they not been intercepted and confiscated as a part of the effort to control the subversive activities of those reunions!

Were the Americans, apart from Everett, innocent accomplices? It is problematical to what extent Bonaparte succeeded in keeping the American Philosophical Society "informed of the most interesting circumstances in relation to the proceedings of the Association," and the results of Everett's collaboration with Bonaparte in publicizing the Congressi in this country are likewise unknown. However, rumors of the perennial conspiracy could hardly have failed to reach the ears of members of the Society, and it is unlikely that they accepted as anything but obvious understatement the wording of Everett's recommendation in behalf of Bonaparte: "I have reason to think that it would be agreeable to the Prince to be authorized & requested by the Philosophical Society to appear as their representative, at the next Annual Meeting of the 'Scienziati Italiani,' which takes place at Naples on the 5th of October next. . . ."[16] Were the Americans aware that in electing the Grand Duke Leopold of Tuscany and Ceva Grimaldi, the Neopolitan prime minister, they were in effect dispensing rewards to them for having furnished trysting places for the notorious Congressi? And does our imagination deceive us, or is there something inordinately insistent in the blunt question of one of the Secretaries in a letter of 31 October 1846: "Why do you not let us know something concerning the last Scientific Meeting at Genoa?"[17] What was anticipated from Bonaparte's announcement of this meeting as something "*grand* and most interesting to Science and civilization"? Interesting questions indeed for the future historian who will analyze the part played by America and Americanism in the ideology and events of the Italian Risorgimento.

Notwithstanding the tenseness of conditions in Italy, the period between 1815 and the middle of the century was very fertile in Italo-American exchanges. A great deal of material was received from Italy, both from institutions and individuals, and much was sent in return by the American Philosophical Society—traffic being particularly heavy with Turin, Naples, and Florence. Relations with the Academy of Turin continued unbroken, and in 1835 Morelli, the Consul General of the Two Sicilies established connections with the Real Museo Borbonico on behalf of his King. In 1846 and 1847, respectively, exchanges were begun with the I. R. Istituto Lombardo-Veneto and the University of Pisa. Consular officials, both American and Italian, often served as intermediaries, and, about 1840, the Society engaged one J. B. Sartori of Leghorn as a regular agent for Italy.[18] The following impressionistic notes in the hand of John Vaughan taken from the first of the two manuscript Letter Books spanning the years 1837–1852 in the possession of the American Philosophical Society are typical and will serve to give some idea of the nature and extent of contacts during this period:

P Brig Oriole-Eager Leghorn

To his Exc^{y} Il. Principe di Cassaro . . .Phil. 30 April 1840

Naples

Sent for the Lib^{y} of the King of two Sicilies N° 9.10 proceeds Copy of Laws of Soc^{y} advised that we had rec^{d} the *Museo Borbonico* no later than the 1, 2, 3 Liv' of Vol 12

Chev^{r} Morelli Naples

Enclosed open to Prince Cassaro advsing we had rec^{d} nothing later than 1, 2, 3 N° 9 6th Volume *Lost* Ital. Dict^{y} Anything for us might be sent addressed to the *Am^{n} Philos Soci^{y}* at Philad—If sent to Phi. to my care as Librarian If to N York to H H Jenks 46 South Street—or may be sent to Alx^{r} Hummett Am Consul at Naples to whom wrote advsing

[15] Appendix, no. 19.
[16] Appendix, no. 17.
[17] Letter Books of the American Philosophical Society.
[18] See title page of *Proc. Amer. Philos. Soc.* **2**: 1841 ff.

Royal Academy of Turin 30 Apr 1840
N° 9.10 proceedings. The Laws—advisd that we had rec^{d} 40th Vol of Trans. of Turin—future packages may be sent to J B Sartori Leghorn who will forward them to me . . .

Charles Lucien Bonaparte 30 Apr 1840
N° 9.10 proceeding & the Laws advised that D. Holbrook was here preparing 4th Vol. of his work. The 3^{d} no published having been ship'd (*illegible*) & caught in the (*illegible*) & remain^{d} all winter to send to Sartori anything he wished to forward

J B Sartori
Leghorn April 30. 1840
Enclosd to him letters to Prince Cassaro—Bonaparte & Turin & advisng that I had requested our correspondents to sent to him anything for our Soc^{y}—He to have everything marked for *Am^{r} Philos Soc^{y}* to the care of J. Vaughan of Phi^{a} H H Jenks of N York N° 46 South Street N York

John Vaughan's notes under the date 10 and 11 August 1840 are no less suggestive:

. . . Naples. Chev^{r} Morelli N° 12
His Exc. Prince Cassaro . . . N° 12
By Brig Treaty—Sartori
Turin Lorenzo Martini. Hyac. Carena—Royal Acad^{y} 12
Rome Chas Bonaparte N° 12
Padua. Zechinelli G. M . . .
Plana, Jean Ast^{r} Royal Turin 11 Aug 1840
Thanks for his Donations See Aug^{t} ms
Sent 1 a 12 Proceedings of A P S—that we had given our attention to Astronomy & wished to Cult. Corresp. had sent (*illegible*) 1840 to the Roy. Acad. & would send 1841 when published—the R Acad had all our Trans'. . .

A word at this point concerning the implications for Italo-American cultural relations of the too little known Committee for History, Moral Science, and General Literature of the American Philosophical Society formed in 1815 and which unhappily was permitted to die a peaceful death a score or so of years later. This committee, oriented as it was about the humanities, had great intrinsic potentialities for establishing new international bonds, and might have contributed to mitigate in the American Philosophical Society that lamentable tendency toward provincialism which seems to have been more or less characteristic of all Western civilization particularly after the middle of the century—a concomitant, apparently, of the growing spirit of nationalism in every quarter. The first volume of *Transactions of the Historical and Literary Committee* (1819) aroused enough interest in Italy that the Florentine *Antologia* offered its readers an extended summary of the contents,[19] and one Morandini later translated the complete work into his language.[20] Two letters of Peter S. DuPonceau, the Corresponding Secretary of this committee, are published in the appendix of this article.[21] With the discontinuation of the publication of the *Transactions* of this Committee, subsequent publication in this field was in the *Proceedings* and *Transactions* of the Society.

One individual deserves particular mention for his unremitting efforts toward the middle of the nineteenth century to increase active collaboration between American and Italian science: Francesco Zantedeschi, physicist, and professor in the University of Pavia. An indefatigable investigator, he actually preceded Faraday in demonstrating that an electric current can be produced in a conductor by the action of magnetic bodies, and seems to antedate Brewster in spectral studies of the absorption of solar rays by the earth's atmosphere. His first communication to the American Philosophical Society is a letter dated Venice, 9 November 1844, accompanying a contribution of three of his works, and the letter terminates:

> I shall hear with the most lively interest the judgment of this distinguished scientific body, to which I ardently desire to belong, for the purpose of establishing a scientific correspondence between America and Northern Italy. It is by the reciprocal communication of ideas that science makes its marvelous advances.

The Minutes of 4 April 1845 take notice of more contributions with another letter expressing the same aspiration. His donations, written indifferently in Italian, French, and Latin, gradually drew the attention of the American Philosophical Society for both their extraordinary frequency and value, and he was elected a member in 1851. Four manuscripts submitted by Zantedeschi on electrical, spectroscopical, and meteorological subjects were published by the American Philosophical Society,[22] three of them in the original Italian, the only articles in that

[19] R. Uzielli, Della storia, dei costumi, e della favella d'alcune nazioni indiane dell'America settentrionale. Epitome degli atti di una accademia americana. IX, pt. B: 71–106, 1823.

[20] See Minutes, 19 June 1829.

[21] Nos. 11 and 12.

[22] *Proc. Amer. Philos. Soc.* 6: 291–298, 333–339, 1859; 9: 372–374, 1865; *Trans. Amer. Philos. Soc.* 11: 117–122, 1860.

language to appear in the publications of the Society.[23]

The flow of exchanges between the American Philosophical Society and Italy was an ever increasing stream from 1850 to the end of the century, despite the chronic disturbances in Italy until 1860, and our own Civil War of 1860–1864. The explanation is to be found in the accelerated tempo of the intellectual life of Italy as she reached estate as a nation, and in the lively sympathy of America in her behalf. The two letters written from Italy in 1861 by George B. Wood, then President of the American Philosophical Society,[24] and the prompt observance of the recommendations made therein, show that the Society shared the general interest in Italy. Old bonds were renewed and fresh ones multiplied, most of them with organizations that had arisen with the new nation. Relations were resumed with the Academy of Bologna, and with the Società italiana delle scienze of Rome whose direct ancestor was the Società italiana of Verona. Exchanges were entered upon with the Istituto Veneto delle scienze, lettere ed arti which had broken away from the parent Istituto Lombardo-Veneto. When the Società Reale Borbonica split into three branches in 1861, the American Philosophical Society promptly established connections with the two that had scientific aims—the Accademia di scienze morali e politiche and the Accademia delle scienze fisiche e matematiche. A swarm of new names appears in the Minutes: the R. Comitato geologico d'Italia of Rome, the Osservatorio Carlo Alberto, the Accademia di scienze, lettere ed arti of Modena, the Pontificia accademia dei nuovi lincei (Rome), the Biblioteca nazionale centrale of Florence, the Biblioteca nazionale centrale Vittorio Emanuele (Rome), the R. Istituto botanico of Palermo, the R. Istituto di studi superiori of Florence, the Società toscana di scienze naturali (Pisa), the Rassegna delle scienze geologiche (Rome), the Società africana d'Italia (Naples), the R. Accademia di belle arti of Milan, Il nuovo Cimento (Pisa), the R. Ministero della istruzione pubblica at Padua, and so on. Usually it was the Italians who made overtures; sometimes the initiative was taken by the Americans, as was the case with the Accademia dei Lincei, the R. Ministero di agricoltura, industria e commercio, and the Direzione generale della statistica, all of Rome.[25]

Another very tangible manifestation of the interest taken by Americans in Italy during this period is revealed by a glance at the list of Italian members of the American Philosophical Society.[26] Seventeen of the forty-three Italians elected to membership since the origins of the Society, or nearly forty per cent of the total, were admitted in the three decades between 1869 and 1901, twelve being chosen in the sixteen years between 1885 and 1901.

And yet, all is not as well as the statistics would seem to indicate. For there is something that we miss increasingly during the years after 1850, an impression not obscured by the tremendously increased volume of matter crossing the Atlantic and by the greater number of Italians elected to membership. One comes to the conclusion that relations between the American Philosophical Society and Italy have become more and more institutionalized, that the spark of personal interest which fired relations in the earlier period, and particularly during the eighteenth century, has gradually become dimmer. A dearth of personal correspondence is one of the signs of the times. With the improvement of the means of transportation, congresses and commemorative celebrations cutting across national lines became more and more frequent, but the great expanse of the Atlantic has remained until the air age just now reaching full development such a formidable obstacle that generally the expedient of inviting foreign members to serve as delegates has been resorted to. Less and less have Italians and Americans sought one another out as individuals to collaborate for the cause of science and civilization.

The pursuance of the present investigation into the twentieth century is a fairly discouraging task. An intensification of the unfavorable factor of nationalism, combined with two world wars, the second of which found Italy in most unhappy circumstances, has had results only too easy to predict. After 1901 no Italian was elected to membership in the American Philosophical Society until the physicist, Vito Volterra, in 1914. Then came the greatest gap in

[23] Zantedeschi was not the first Italian to submit material to the American Philosophical Society, for Deabbate and Morelli had previously transmitted compositions, which, however, were not accepted: see MS. Communications to the American Philosophical Society, II (Philology, Literature, Antiquities, &c.), and Minutes, 16 January 1835.

[24] Appendix, nos. 24 and 25.

[25] See letter no. 17 of appendix; and Minutes for 7 November 1890.

[26] See appendix.

the history of personal relations of the Society with Italy—twenty-five years—to the election of Enrico Fermi[27] in 1939. In the year 1901 there were at least eleven living Italian members; by the end of the First World War, the number had dropped to five; at the time of Fermi's election Vito Volterra was the sole living Italian member.

Evidence from the accession books corroborates the deductions from the membership list: a perusal of the records since 1900 for that surest of all indexes to active interest and cooperation—the individual donation—is a well-nigh fruitless task. However, exchanges with Italian societies are frequent, and a glance at the mailing list for publications of the American Philosophical Society in effect at the outbreak of the Second World War[28] will suffice to prove that this aspect of the collaboration of the Society with Italy has not suffered perceptibly.

The trend since 1870 or so is not devoid of certain promising features. The American Philosophical Society has become noticeably more discriminating in its choice of Italians as corresponding members—and more broad-minded, to judge from the increased range of activities represented. A most encouraging sign is the fact that, while the number of Italians elected has decreased, the percentage of those for whom a criterion of membership seems to have been cooperation with American science has steadily increased: Secchi, Capellini, Sergi, Marconi, Volterra, Fermi, and Levi-Civita being cases in point. Furthermore, a systematic revision of policy in the matter of exchanges with Italian organizations now being contemplated[29] will eliminate many of the shortcomings of the haphazard procedure heretofore followed, and by integrating the efforts of the American Philosophical Society with neighboring institutions will ultimately effect a notable improvement in Italo-American cultural intercommunications. Meanwhile, the recent election of the dean of Italian liberals, Benedetto Croce, and the distinguished classical scholar, Gaetano De Sanctis, bespeaks a healthy present interest in Italy on the part of the Society, and presages well for the future.

It is a foregone conclusion that the long international associations of the American Philosophical Society render its archives and library a valuable source of material for the scientist and historian. It is hoped that the present survey will have at least demonstrated that the manuscript documents—Minutes, Donation Books, Letter Books, correspondence, etc.—are a rich store for the Italo-American comparatist. The collection of printed books—particularly those of a scientific nature—which the American Philosophical Society has acquired by virtue of its contacts with Italy during the better part of two centuries is large and varied, and in many cases the intrinsic worth is enhanced by autographs. In the Library of the Society we find the precious initial volumes of the academies of Turin and Bologna, of the Società patriotica of Milan and the Società italiana of Verona. Personal contributions have come not only from Italy, but from Italians in the United States, South America, even from far away Malta. Sometimes donations representing Italian science are by authors with such un-Italian names as Jakob Gråberg af Hensö, or Josephus Slop de Cadenberg. By courtesy of the authors, the Library of the American Philosophical Society can count among its holdings such works as Giambatista Beccaria's *Della Elettricità terrestre atmosferica a cielo sereno*, Felice Fontana's *Ricerche fisiche sopra l'aria fissa*, Luigi Castiglioni's *Viaggio negli Stati Uniti dell'America Settentrionale*, Mauro Rusconi's *Descrizione anatomica degli organi della circolazione delle larve delle salamandre acquatiche*, Lazzaro Spallanzani's *Opuscules de physique animale et végétale*, Gianrinaldo Carli's *Lettere americane*, Amedeo Avogadro's *Fisica de' corpi ponderabili*, Alessandro Saluzzo di Menusiglio's *Histoire militaire du Piémont*, Carlo Botta's *Storia della guerra d'indipendenza degli Stati Uniti d'America*, Charles Lucien Bonaparte's continuation of Alexander Wilson's *American ornithology*, Giovanni Plana's *Mémoire pour le mouvement d'un pendule dans un milieu résistant*. Contributions range in subject from Sergi's *Natura ed origine della delinquenza* to Meneghini's *Paleontologia dell'Iglesiente in Sardinia*, from Schiaparelli's *I Primordi dell'astronomia presso i Babilonesi* to Luigi Bellardi's *Saggio di ditterologia messicana*, from Cannizzaro's poetical volume, *Tramonti*, to Volpicelli's *Del Moto rettilineo lungo un sistema di piani diversamente inclinati e contigui*. Many donations are of interest if only for the overtones awakened by their titles: Domenico Morelli's *Sopra una*

[27] Whom we shall count, even though he was elected as a "resident" member.

[28] See appendix.

[29] See Report of the special committee on the future policy of the Library, in *Year Book* for 1941: 275–281, 1942.

meteora luminosa osservata in Filadelfia, Giacomo Sega's *Componimenti poetici d'un italiano profugo in America*, Luigi Tinelli's *Hints on the cultivation of the mulberry with observations on the production of silk*, Carlo Passerini's *Notizie sulla moltiplicazione Firenze negli anni 1837, 1838, 1839 dell'uccello americano Paroaria Cucullata, chiamato volgarmente cardinale*, Lorenzo Billia's *Un Moralista americano*, Luigi Ambiveri's *Agli Avversari della piacentinità di Cristoforo Colombo;* yes, even Giuseppe Tassinari's *Fascist economy*, published in Rome in 1937 and presented to the Society by the Consul General of Italy.

This survey of the relations of the American Philosophical Society with Italy has proved to be by and large an epitome of the development of the cultural exchange between America and Italy, and the ramifications of the subject have been more numerous and varied than one might have expected. Burgeoning in the most auspicious of eras, reaching full international stature with prodigous rapidity, largely by virtue of its association with Franklin, the Society became almost at once the center to which all Europe, including Italy, turned for information regarding the New World; and the Americans, on their part, were not averse to establishing connections with a country whose energies, thwarted in many spheres by reason of political slavery, had turned to science as one of the possible outlets, and with brilliant results. During the first part of the nineteenth century the cosmopolitan motive of collaboration in science for its own and humanity's sake seemed to weaken, but the Italians' interest in America continued unbroken, inspired predominantly, it seems, by their view of America as a source of comfort and encouragement in their unhappy political condition; the American Philosophical Society figured in this new orientation of Italo-American interests, and the members seem to have divined and sympathized with the temper of the Italians. One may attribute the great flood of exchanges and rapid increase in the number of Italians admitted as foreign members of the American Philosophical Society during the latter part of the nineteenth century largely to the burst of scientific and literary activity that attended Italian unification, and to the fact that the Society shared the world's admiration for Italy's achievement. There seems even to have been a sort of inversion of traditional roles for a while after 1860—the Americans in the throes of a civil war casting envious eyes upon Italy, happy in her unity, and bending her undivided energies to progress in every sphere of activity.[30] Notwithstanding the augmentation in material traffic between America and Italy, an increasing tendency toward spiritual isolationism on the part of the two nations can be inferred from the tone of perfunctoriness and impersonality which becomes progressively more pronounced in the documents relating to the American Philosophical Society after the middle of the nineteenth century; and the twentieth century, with no impelling attractions to draw the two countries together, has been to date the most barren in meaningful contacts between the American Philosophical Society and Italy. This phenomenon is somewhat puzzling because until the outbreak of World War II there have been no real obstacles to a continued intellectual rapprochement. Perhaps such a state of affairs became inevitable with the intensification of intellectual life within each country and the concomitant multiplication of organizations of all kinds. It may be this circumstance which explains the emergence of such a body as the Smithsonian Institution with its elaborate international machinery for the coordination of scientific effort and transfer of scientific material, functions which in more leisurely times were solicitously discharged by the separate societies. There is reason to suspect that studies in the interrelations of the various American and foreign learned societies will reveal that the case of the American Philosophical Society and Italy is but symptomatic of a general situation.

However that may be, it is to be hoped that the spirit of international cooperation in science, grown dim through the decline of vitalizing personal interest, will quicken with the fresh realization that the world of learning is one, and that the new cosmopolitan age which appears to be dawning will witness the accumulation of another store of material in the archives of the American Philosophical Society for the entertainment of some future Italo-American comparatist.

[30] See for example letter no. 24 in appendix.

APPENDIX

LETTERS*

1. *Giuseppe Angelo Conte di Saluzzo di Menusiglio, President of the Academy of Turin, to the American Philosophical Society*

Copia della risposta della Società Reale di Torino alla Società Filosofica Americana.—

La Società Reale delle Scienze di Torino ha ricevuto con . . . (*sic*) la gratitudine il scientifico regalo della Società Filosofica Americana, ed avuta l'approvazione di Sua Maesta accetta la Corrispondenza d'un Corpo composto di membri Illustri e Celebri, ed in contrassegno della sua stima e riconoscenza Le invia le sue Oper già stampate, riservandosi di farle pervenire quelle che seguiteranno per Mantenere colla maggior premura la richiesta onorevole cooperagione p il vantaggio delle Scienz ed Arti.

Torino 30 Giugno 1773—
CONTE SALUZZO P . . . (*sic*)
della Società Reale—

Copy of the Answer of the Royal Society of Turin to the American Philosophical Society.—

The Royal Society of Sciences in Turin have recieved with the utmost Gratitude, the Scientific repast of the American Philosophical Society, & have (with the approbation of their President) accepted of the Correspondence of a Society compos'd of such Illustrious & Celebrated Members, & as a token of their gratitude & Esteem, they have sent them such of their Transactions, as were already printed, assuring them that they will send from time to time all their future publications in Order to Maintain (with the greater Security) their Desire of an hon^{ble} Union for $\underline{e}$ Advancement of $\underline{e}$ Arts & Sciences.—
$\underline{y}$ $\underline{y}$

Turin 30 June 1773—
COUNT SALUZZO PUND of
The Royal Society.—

2. *Sebastiano Canterzani, Secretary of the Academy of Bologna, to the American Philosophical Society*

Illmī Sig^{ri} Sig^{ri} Pronī Colmī—

Ho avuto l'onere di presentare in nome delle Sig^{rie} Loro Illmē a quest'Accademia dell'Instituto il primo Volume delle Loro filosofiche Transazioni. L'Accademia è stata sensibilissima all'onore, che le fanno, e alle corresissime espressioni con cui si sono compiaciute le sig^{rie} Loro Illmē d'accompagnare il Loro dono. Ella si reputa ben fortunata di avere corrispondeza con una Società . . . (*sic*) che la compongono e per Il fine nobillissimo, che si ha proposto, e che così felicemente . . . (*sic*) come il dimostra ben chiaro questo primo volume di memorie' . . . (*sic*) interestantissime. Applaudisce pertanto ai Loro taleti, e al Loro Zelo, e nudre verso di un cosi rispectabile Ceto uno Spirito di viva riconoscenza unita ad una profonda stima e considerasione. Questi sono i sentimenti, che ella m'ha incaricato di significare alle Sig^{rie} Loro Illmē: e così potesti io venderlitali, quali sono da lei usciti, per farli Loro riuscir graditi. Però supplico le sig^{rie} Loro Illmē: a voler con la Loro bontà supplire al difetto delle mie espressioni, mentre glorioso dell'occasione' che ho di umiliar Delle Sig^{rie} Loro Illmī.—

Bologna li 18 Agosto. 1773
Umilmō, deutmō, ed Obbligmō,
Servitore SEBASTIANO CANTERZANI
Segretario dell Instituto, e dell
Accademia delle Scienze di Bologna

To the Illustrious & c. Members of the philosophical Society.—

Gent:/

I had the Honour of presenting in the name of the Illustrious Members of your Society, the first Volume of your Transactions to the College & Academy of sciences of Bologna. The Academy is very sensible of the honour done them, as also of the very Elegant Letter with which they were pleas'd to accompany their gift. They esteem themselves happy in corresponding with the Society upon the subjects the have in view, as well as upon those Subjects on $\underline{c}$ they have written, in which the have
$\underline{w}$
so happily succeeded, as the first volume of their Transactions so full of Interesting memoirs demonstrates. The Academy of Bologna applaud their Talents & Zeal & return their most Sincere thanks join'd with the most profound Respect & Esteem. These, Gentlemen, are the Sentiments they have charg'd me to transmit to you. Happy shall I esteem myself If I have deliver'd them (such as the came from, the Society) so that they may be agreeable to you. I beg you would supply from your goodness the defect of my Expressions. In the meantime I rejoice in offering you the most respectful veneration & obedience. I have the Honour to subscribe myself your most Sincere—most devoted & most obliged Serv^{t}

Bologna 18 Augs^{t} 1773— SEBASTIAN CANTERZANI
Secretary of the Academy of
Sciences at Bologna—

* Where the location of the original letters published in this appendix is not given below, that information will be found in the body of the article.

The texts as published here are diplomatic except for a few cuts (indicated by the customary dots) and an occasional supplement to the punctuation to facilitate comprehension.

3. *Felice Fontana, President of the Accademia del Cimento at Florence, to the American Philosophical Society*

Ornatissimis Viris GUILLELMO SMIT, et ROBERTO STRETTEL JONES Academiae a Secretis

FELIX FONTANA S. D.

Magnus Hetruriae Dux Leopoldus pro incredibili ejus in Litteras amore non sine summo grati animi sensu prosecutus est eximium opus, quod Illustris isthaec Philosophica societas Florentinae Academiae perhonorifice largita est; mihique ut vobis animi sui sensa significarem, clementissime imperavit, ac interea dum Florentina Academia felicioribus surgit auspiciis (quo brevi faustissime continget) ut litterarum vobiscum inirem commercium praecepit. Interim certe nec sumptibus, nec Laboribus parcitur, ut digna tanto Principe, digna Italici nominis gloria, digna huius secoli splendore instauretur Academia. Ampla cumprimis colligitur Historiae Naturalis suppellex: Humani corporis partes singulae summo Studio, atque incredibili sagacitate, et industria a peritissimo Artifice cera effinguntur, quod sane opus perfectione, et praestantia quidquid huiusque in universa Europa ab aliis praestitum fuit, longe excellet: exquisitissimae omnis generis tum Physicae, tum Astronomiae machinae, necnon Mathematica organa elaborantur; nihil denique praetermittitur, quod Academiam absolutam, et perfectam possit efficere. Harum rerum omnium cura mihi demandata est a providentissimo Principe, penes quem experimentali Physici, et Mathematici munus sustineo. Ac mihi quidem nihil unquam erit antiquius, quam sagacissimi, et optimi Principis votis, cogitatis, et pubblicae expectationi respondere. Enimvero a Magno (liceat Posteritatis vocabulum usurpare) Leopoldo, quem tutelarem Hetruriae, ac Italiae Genium exterae etiam gentes dudum suspiciunt, nihil est nisi magnum nisi eximium, nisi undequaque perfectum expectandum; "Nil non sperandum Teucro Duce, et auspice Teucro.

Valete interim, egregii Viri, ac Rei Litterariae decus, ea, qua coepistis, animi contentione sustinete.

Florentiae Idibus Junii

4. *G. W. Logan to Humphry Marshall*

Sir

We wish to be informed if we can be supplied with any of the Natural productions of America, either by barter for the productions of Italy, or at a moderate price. Quadrupeds, Birds, Insects, Worms, or Serpents, the last of which may be preserved in Spirit of wine. Minerals, Seeds and Plants, particularly that plant called *Dionea Muscipula* which is found in low marshy places in South Carolina. For such articles we shall be willing to pay the customary price or return the value of them in such plants as we are in possession of; a Catalogue of which we now send you. If any Gentleman of the Philosophical Society of Philadelphia is willing to enter on such a friendly intercourse with the Royal Museum of the grand Duke, they will please to address their Letters to Monsieur L'Abbé Fontana

à Florence—

Respected Friend

The above is a translation of the Letter from the abbe Fontana. I have taken the earliest opportunity of sending it to you, in which I have been in some degree influenced by the necessity of informing you, that M.r Williams will sail by the 15.th of next month. You will be the best Judge of what Plants or other Natural productions may with safety be sent by the present opportunity. I wish you to write to the Abbe, give him such information as you may think proper and testify your desire of doing anything in your power to serve that grand Institution. If agreeable I will enclose your Letter in one I shall write to the Abbe; you must not be concerned on account of you writing in English. I think this gentleman has been in England and is sufficiently acquainted with the Language to understand it, tho' not to write it with correctness. Any little collection you may send to my care, shall be forwarded.

I am

Your Assured Friend

G. W. LOGAN

Philad.a August 26.th 1783.

5. *Felice Fontana to Humphry Marshall*

Pisa, in Tuscany, 16th January, 1784.

Sir:—

It is with a great pleasure that I have received through Captain HUMPHR. WILLIAMS, the favour of your letters, and the two boxes of American plants, which you was so good to forward to us; which came almost all alive, and hope they will thrive well in our country. Captain WILLIAMS may inform you by what accident I am not in Florence now; and consequently it is not in my power to send you anything, except few seeds that I shall endeavour to get from the garden of the University, reserving to me self the pleasur to send you something more by the first occasion. However, I must confess to you the greatest gratitude and obligation, both by the pleasure you have made to us, as well as by that I have had in stiling myself, with the greatest respect and consideration,

Sir, you most humble and odedient servant,

FELIX FONTANA.

6. *Adamo Fabbroni*[1] *to George Logan:*

Sir!

I take the opportunity of Cap.t Williams voyage to America for applying myself with a phylosophical Liberty to a free American Philosopher as you are: It is by such a title that I dare (unknown as I am) to apply myself to you, and beg the favour of your assistence. The perusal of the first volume of the Philosoph. Transactions of your celebrated Society of Philadelphia inspired to me as well as to every one the greatest respect and veneration for such a respectable Body, and for the worthy and judicious members of it. I published lately two small pamphlets upon subjects as curious, in my mind, as neglected by Learned men, and wished to offer those feeble productions of mine to your Society as a mark of my great esteem and veneration. Such is the favor that I beg from you, and hope you will be so good of giving me the opportunity of serving you in Italy.

I have heard that a very curious ancient inscription of a hyeroglyphic kind was found deeply engreaved upon a rock near the sea some time ago in your continent, and if I recollect well in New England. This inscription was sended by a professor of one of your Universities or Colleges to that eminent Etimologist and Philosopher M.r Court de Gibelin in France, who pubblished it in one of his great work's volumes intitled *Le Monde primitif* & c. I was not fully satisfied with his explication, and was brought by some hints of my (?) to write a dissertation on the subject. Could I, through your kindness, get some better informations about those hyerogliphics, about the reality of their being ancient, about the rock on which they are ingraved, & c. & c.? Could I have besides a rough sketch of the inscription itself? I should be exceedingly obliged to you for such a favour, and offer my best services in Italy to you and to your Accademy. Perhaps it may be agreable either to you, to your friends, or to the celebrated Society to have regular informations from this country about arts and sciences.

If you think proper to make an answer to this letter, you may direct it to François Favi Esq.r, Agent for his Royal Highness the Grand duke of Tuscany at Paris in France; for I know that there is very frequent occasions of vessels going from Pensylvania to France; so that by that way you may have an early opportunity to give your orders to one who wish to stile himself with the greatest respect and veneration

Sir

Your
most humble most obedient
and faithfull servant
ADAM FABBRONI

Perugia 15 January 1784
nello Stato Pontificio

N. B. The letter to be directed to M.r Favi hereupon mentioned for sending them to me at Perugia.

7. *Paolo Frisi to Benjamin Franklin*

Depuis mon depart de Londres je ne vous ai ecrit, Monsieur, que pour vous remercier du beau present que vous m'avez fait de vos ouvrages, et j'ai appris par le gazzettes publiques les grandes nouvelles qui vous regardoient directement, celles de la revolution de l'Amerique. J'espere cependant que vous ne m'aurez pas oublié, et je vais profiter de toute la bonté que vous m'avez temoignée autres fois en vous presentant mons.r le Chev.r Castiglioni gentilhomme d'une maison de plus distinguées de nôtre ville qui compte de faire un tour dans l'Amerique pour voir de près cette brave et nouvelle Nation, et pour y continuer ses recherches sur l'Histoire Naturelle. Je l'ai chargé de presenter mes deux premiers volumes à l'Academie de Philadelphie. Je vous prie de le diriger. Vous aurez des nouveaux droits sur la reconnoissance comme sur le vrai le profond respect avec lequel j'ai l'honneur d'etre

Vôtre très humble très obeissant serviteur
Monsieur à Milan ce 30 Mai 1784

FRISI

8. *Carlo Amoretti, Secretary of the Società Patriotica of Milan, to Benjamin Rush*

Mons.r le Chevalier Castiglioni a fait signifier à notre Societé par M.r le Comte Castiglioni son frère, que la Société Philosophique de Philadelphie entreroit volontiers en correspondance avec nous pour établir ainsi une comunication de connoissances utiles à l'agriculture, & aux arts.

Tous les Membres qui étoient à l'assemblée ont sur le champ senti combien ce commerce literaire seroit glorieux & utile pour nous. On a nommé parmi les associés correspondans son Excel. M'r. le Docteur Franklin Président de votre Société, & vous, Monsieur, & en m'enjoignant de vous en envoyer les lettres patentes. Elles vous parviendront, Monsieur, avec les actes de notre Société, & quelques autres livres qui ont paru chez nous, & que nous avons cru pouvoir vous faire plaisir.

Nous connoissons le premier volume des actes de la Société de Philadelphie, & j'en ai traduits quelques Memoirs dans un'ouvrage periodique qui se publie chez nous. Ainsi nous sommes bien surs de profiter

[1] Brother to Giovanni Fabbroni, at the time Fontana's assistant in the Cabinet of Natural History of the Grand Duke of Tuscany. Adamo Fabbroni later acquired a considerable reputation as a naturalist and archeologist.

This letter is in the collection of the Historical Society of Pennsylvania.

de vos lumieres; puisque les sciences utiles sont cultivées chez vous avec tout le soin & le plus grand succès à l'ombre du pacifique olivier planté par la main de la liberté & de la sagesse.

Parmi les livres que j'enverrai, vous y trouverez, Monsieur, *Gli Elementi d'Agricultura* avec des notes relatives à l'agriculture Milanoise, où vous pourrez voir les articles que nous cultivons, & s'il y aura quelques graines ou sémences que vous souhaitiez, nous nous ferons un plaisir de vous les fournir.

Persuadés que votre Société voudra bien agréer nos offres, nous osons vous prier de nous envoyer en échange des graines d'arbres, arbustes, ou plantes utiles à l'economie domestique, & champetre, & aux arts, qu'on cultive plus particulierement chez vous.

Le R. P. Pini Professeur d'Histoire naturelle, dont vous trouverez quelques ouvrages dans la caisse, profite de la même occasion pour envoyer quelques articles de mineraux à M^r^ Vaughan de votre Societé, que vous trouverez enfermés dans la caisse même. Je l'addresserai à M^r^ Motteux & Comp^e^ à Londres pour la faire passer a M^r^ Morris negoc^t^ à Philadelphie, qui vous la remettra.

Je joins ici la note des livres contenus dans la caisse.

Veuillez, je vous prie au nom de notre Société assurer la Société Philosophique & son illustre Président, que comme nous nous férons une gloire d'être en correspondance avec vous, nous nous ferons toujours un plaisir de vous rendre tous les services qui dépendent de nous. En mon particulier je vous offre mon obéissance jointe aux sentiments de l'éstime & du respect avec lesquels j'ai l'honneur d'être

Monsieur à Milan ce 8 Avril 1786
Votre très humble & très obeissant serv^t^
CHARLES AMORETTI secretaire perpt.
de la Soc. Patriotique.

9. *Carlo Amoretti, of the Società Patriotica, to Benjamin Franklin*

Excellence

C'est une gloire pour notre Société de pouvoir compter parmi ses Associés Correspondans un des plus grands Genies du Siecle, & le Bienfacteur des deux Êmispheres; & c'est aussi un bonheur pour moi, que d'être l'interprete de ses Sentimens. Elle me charge de prier Votr'Excellence de vouloir bien agréer le témoignage de la plus haute consideration, en consentant d'être son Associé Correspondant; car elle est bien sure de profiter de vos lumieres, qui, embrassant toutes les branches des connoissances humaines, savent les faire concourir au bonheur de l'humanité. Nous ne doutons pas de puiser chez vous des instructions importantes, même à l'égard de l'agriculture, quoique cet art precieux soit en honneur chez nous dépuis le XIII siecle. C'est alors que des mains republicaines le releverent avec toute l'énergie de la liberté de l'annéantissement où l'avoit jetté l'esclavage féodal. Mais le meilleur des Souverains vient de faire bien plus à présent par l'égalité des taxes, par l'uniformité & la simplification des loix, par la diminution des impots, & surtout par la liberté, redonnant à l'Industrie toute sa vigueur; & notre Societé se croit bien fortunée de pouvoir feconder ses soins paternels.

C'est pour nous mieux acquitter de ce devoir sacré, que nous cherchons à avoir des Correspondans dans les Païs étrangers, pour profiter de leurs connoissances: C'est à cet objet que nous prions la Société Philosophique à laquelle V. E. préside, à nous communiquer soit les productions de la terre, qui ne nous sont point cõmunes, soit les lumieres qui font fleurir chez vous l'Agriculture & les Arts.

Outre quelques livres, dont notre Société fait présent à la votre, & dont M. le D^r^ Rush vous aura sans doute déjà parlé, je joins dans le Pacquet de V. E. le premier volume des Actes de notre Société, & quelques papiers que la Société vient de publier.

Je suis trop peu de chose pour offrir mes Services à V. E., mais je me croirois bien fortuné si j'étois honnoré de vos commandemens pour vous temoigner par le fait la haute éstime, & le profond respect avec lequel j'ai l'honneur d'être

De V. E.

Milan ce 15 Mai 1786
Votre très humble & très obeissant
serviteur CHARLES AMORETTI Secret.
perp. de la Société Patriotique.

10. *Count Carlo Luigi Morozzo and Tommaso Valperga Massimo conte di Caluso, of the Royal Academy of Sciences at Turin, to the American Philosophical Society*

Messieurs

L'Académie Royale des Sciences de Turin prie, Messieurs, votre Illustre Société d'agréer ces volumes, comme une preuve, un effet de son empressement à entretenir le mieux qu'elle peut, une Correspondance dont elle fait gloire, dont elle voit avec satisfaction dans sa bibliothèque naissante un gage précieux, le premier volume de vos Transactions.

Nous sommes flattés, Messieurs, que la Commission que nous avons de notre Compagnie de vous témoigner ses sentimens, nous donne un titre à vous assurer nommément de l'estime très-distinguée avec laquelle nous avons l'honneur d'être

Messieurs
Vos très-humbles et
très obeissans Serviteurs
Le C^t^ MOROZZE & l'AB. DE CALUSO
Turin le 8 fevrier 1787

1. *Peter S. DuPonceau to J. B. Sartori*

Philad[a] 12[th] Oct. 1818

My dear friend.

As I have always known you willing to oblige, I beg that when you have an opportunity to write to Rome you will try to procure the Catalogue of the Books printed for and by order of the Congregation De Propagandâ fide, and also the Book of which the title follows:

"Hyacinthi Bruscotti de Vestralla; Grammatica Linguae Angolensis, & Catechismus in eâdem linguâ, Romae, Typis Propagandae"

These books are for the American Philosophical Society, and I shall see that the Cost be duly & immediately reimbursed.

I am with great affection—

Your sincere friend

PETER S. DUPONCEAU

12. *Peter S. DuPonceau to Morandini*

MR. MORANDIN S. A. C. Philad[a] 29[th] Nov[r] 1824
Italy

Sir, Your letter addressed to me (without date of time or place) arrived while I was absent on a journey, & owing to the scarcity of opportunities for Italy, & other circumstances, I could not answer it so sooner as I would have wished. I have now the honor, Sir, to enclose to you agreeably to your request a copy of the Transactions of the Historical Committee of the Philosophical Society, which I have obtained for you from the Committee & it is the last Copy which they had remaining. I enclose also by their desire a Copy of the Catalogue, which has been recently printed, by which you will find that their library is very small, but is daily & rapidly encreasing. I also enclose a Pamphlet communication on the languages & c. of the Berbers of Africa which may be interesting to you. The Society have published nothing else since 1818, but the Second Volume of their Philosophical Transactions (New Series) is in the press, & will soon appear. They will also soon put to press the Second Volume of their Historical and Literary Transactions, which will consist principally of Philosophical pieces respecting the languages of our Indians.

Our Society feel very much the difficulty of communicating with your country, the more so as several of our members understand & relish your language, which is becoming very fashionable among us; but we have no[t] yet seen a single literary journal from any part of Italy, & we do not know in fact what your literati are doing. We would be very glad to be informed of it, & particularly whether anything has lately appeared about the Tuscan, Oscan, & other antiquities of the Latin tongue. We have very few helps here that can throw some light upon those origins, in which we feel a great interest.

I shall feel very much honored, Sir, by your correspondence, & happy to render you any service in my power in this part of our Country.

I am respectfully

Sir Your most obed[t] hum Serv[t]

PETER S. DUPONCEAU[2]

13. *C. L. Bonaparte to Edward Everett*

Rome Dec. 15. 1840

My dear friend

Few things could have been more agreable to me than the reception of your kind & friendly letter of Nov. 28 which I only received two days ago; especially as I cannot but anticipate the pleasure of possessing yourself & family for a good length of time in this our eternal city. Do not deprive me of that due assurance & do calculate upon me for whatever may be in my power to do for you during the time you will grant us.—I recollect your proposition of writing each other once a month & certainly we are both guilty of breaking that agreement.—Your absence from America has however caused you the trouble of receiving my letters & circulars which I begged you would make known on the other side of the Atlantic.—Yes my go[od] friend, I have succeeded (& you cannot imagine again[st] how many difficulties) in founding an Institution which will in a very short time change the face of this fair peninsula. I write you after an article which you will perhaps translate, arrange, & have published both in England & America. You will easily perceive it has been written as you say at Washington *"for home consumption!"*—Our next meeting at Florence will be *grand* & we want some *Americans.* I write this very moment to our future President M[ris] Ridolfi presenting you as well as to Vieusseux & telling him that you must be our *transatlantic Apostle.* Find him out, pray, for I can not give him your adress, go at Vieusseux's plan[n]ing meetings on Thurday's evenings *in my name;* advise our friends in their work of emancipation & you will do good to science, Italy, & human kind at large.—You will soon feel at ease with our friends. Excuse my tremendous haste & especially my wretched English of which I have lost the habit. A thousand thanks for your welcome present which I have devoured & which made me pleasantly renew my old acquaintances the birds of *Freedonia* & encreased my *regrets* not to have made any at the time with your most interesting Ichthyology.—Should you answer as I hope the present, I'll continue to trouble you with my schemes & ask your active cooperation in a great many things which will probably please your noble & elevated mind: But why select Florence rather than Rome where

[2] This letter, and the preceding one, exist as contemporary copies in the MS. Letters of the Historical and Literary Committee owned by the Library of the American Philosophical Society.

leaves [lives?] one of your most devoted and enthusiastic friends

CHARLES PRINCE BONAPARTE
Pce of Canino[3]

14. *Edward Everett to C. L. Bonaparte*

Florence 22 Decr 1840

My dear Prince,

I was extremely gratified to receive your letter of the 15th & to learn from it, notwithstanding the long interruption of our correspondence that I shall have a place in your friendly recollection. I shall take pleasure in translating & adapting for our American Papers the notice of your second Scientific Meeting; & should I be in Florence or within any moderate distance of Florence next October, I shall feel proud of being permitted, under your auspices to make my appearance among the learned men who will attend the third meeting. I have since my arrival at Florence been in the habit occasionally of going to the Vieusseux's on Thursday Evg's & since you are good enough to say that you shall mention my name to the Marquis Ridolfi, I shall take the liberty to call on him. I congratulate you on your success in establishing this intellectual congress & I agree with you that it is capable of producing the most beneficial effects & of counteracting (as far as the progress of improvement is concerned) the want of political centralization.

I was induced to fix my residence at Florence for the winter, from the supposed conveniences for strangers in house-keeping & the superior cheapness of living. I have engaged apartments in the Casa Lagerswärd till May. My movements, after that time are somewhat uncertain. If I remain in Italy, as I probably shall, I shall be disposed to seek a summer residence cooler than Florence; & I should be glad to divide the next winter between Naples & Rome. I assure you, it would constitute a very strong attraction toward the latter place, that it would afford me the gratification & advantage of your society.

I assure you it will give me the greatest pleasure to hear frequently from you in the meantime. However neglectful I may have been in times past, I am willing you should judge hereafter of the value I place upon our correspondence by the punctuality with which my part of it will be performed. Your English needs no apology, but if more agreeable to you to write in Italian, I shall be able to read your letters in that language.

Begging you to accept the assurances of my respectful attachment, I remain, my dear Prince, faithfully & affectionately yours.[4]

[3] Letter in the Massachusetts Historical Society. It is written on a blank leaf of a circular giving a brief account of the second meeting of the Scienziati Italiani, and announcing the third at Florence in 1841.

[4] Letter Books of Edward Everett in the Massachusetts Historical Society.

15. *Edward Everett to C. L. Bonaparte*

Careggi, near Florence 15 June 1841

My dear Prince,

I have just heard of your return from London, by the Vieusseux and of your kindness in enquiring after me. I much regret that my absence from Florence & your rapid passage through the city put it out of my power to have the pleasure of seeing you & thanking you in person for the kindly sentiments expressed in the letters you have been so good as to write me, since my arrival in Italy.

You circular kindly transmitted me on the 12th of Decr last the 7th of January will afford my countrymen some general information relative to the Scientific Congress & your meritorious efforts in creating it. The approaching session, in which you will no doubt take a leading part will furnish a still more favorable opportunity for a more distinct & detailed notice of your exertions in this cause. Indeed it seems to me that in bringing about this scientific organization you confer upon Italy many of the advantages of that Unity, for which some political theorists sigh; of which the benefits would probably be counter-balanced by some serious evils. . . .

I look forward with much pleasure to the opportunity of meeting you in October on occasion of the Scientific Congress; and as I propose to pass a considerable part of next winter in Rome I hope to have happiness of many occasions of a renewed cultivation of your acquaintance.

In the meantime, I beg you to believe me, with sincerity, my dear Prince, your obliged friend & obedient servant.[5]

16. *C. L. Bonaparte to J. K. Kane, Secretary of the American Philosophical Society*

Florence, July 29 1842

Sir

Your kind assurance that our meeting at Padua should be honored by several of your scientific characters has proved so agreeable to us that at the moment of seeing it realized, I cannot restrain from expressing you my anxiety to receive some transatlantic friends & c. You must also be informed in due time that next year (1843) we meet *at Lucca*.— The death of Mr Vaughan has deprived me of one of my best friends & American correspondents, & I shall be happy to correspond henceforth with you. Through Mr. Ord the Ph. Soc. will receive the last Nos of my Fauna now completed after ten years hard labour. May I hope these numbers will be entered as a donation from myself. I anticipate with much pleasure a scientific tour which I calculate to make in your happy country early in 1844 with my eldest

[5] *Ibid.*

son born in Philadelphia & now 18, & Dr Mais his able tutor, & the celebrated Agassiz. Our plans are vast & we are come to find sympathy in your noble land.—We were delighted to have among us in Florence my old friend Mr Everett now Min. in London. The Transactions of the three *Congress'* have been published each year in succession & I am astonished you did not receive any of them. At all events Mr Ord can show you his copy of the last.—Could I suggest the Election as a member of the Am. Ph. Soc. of that enlighted Gov. the grand Duke of Tuscany already of the Roy. Soc. of London & c who has done so much for science? Please to direct your answers, *with many commands*, in Rome where I shall be in October as soon as the meeting of Padua is over. I am glad to see my *Amphibia Europea* & *Prodromes Syst. Herp* had reached, but fear the other works not mentioned had not. Excuse my haste & believe me,

Sir

Your most obt

CHARLES L. BONAPARTE
Pce of Canino[6]

17. *Edward Everett to George Ord, Librarian of the American Philosophical Society*

London, 14 March, 1845

Dear Sir,

I transmit by the next steamer a letter for you, which I received yesterday from the Prince of Canino and Musignano. I have reason to think that it would be agreeable to the Prince to be authorized and requested by the Philosophical Society to appear as their representative, at the next Annual Meeting of the "Scienziati Italiani," which takes place at Naples on the 5th of October next. A simple letter requesting the Prince to appear in that capacity, signed by the President or Secretary would be an adequate commission.—

You are too well acquainted with his scientific character to need any observations from me on his fitness to appear as the representative of a learned body. The fact that one of his principal works is devoted to the illustration of the natural history of the United States would give peculiar fitness to his designation for the purpose mentioned.—

Should you have occasion to communicate with the Prince on this or any other subject, a letter enclosed to me and sent to the department of State at Washington, would reach me without expense.

I am, Dear Sir, with great respect,
Your obedient servant,

EDWARD EVERETT.[7]

[6] Letter in the American Philosophical Society Library.

[7] In the Everett Letter Books of the Massachusetts Historical Society.

18. *"Extract of a Letter from the Prince of Canino and Musignano, Charles L. Bonaparte, to the Librarian [of the American Philosophical Society,] dated Rome, 12th July, 1845."*

I am much gratified in having been chosen as the Representative of the American Philosophical Society at the Seventh Congress of the Italian Association, to be held at Naples in September next. Pray have the goodness to offer to the Society my most respectful acknowledgments for the honour conferred upon me. It shall be my duty to keep you informed of the most interesting circumstances in relation to the proceedings of the Association; and from the position which I shall occupy in that learned body, as the Society's representative, I shall be enabled to procure for your library all the published Transactions, as well as the Medals, & c which may be issued on the occasion.

Pray convey to Dr. Dunglison my thanks for his official letter.[8]

19. *"Extract of a letter from the Prince of Canino and Musignano to the Librarian [of the American Philosophical Society], dated Rome June 8, 1846."*

Notwithstanding my irregular *mandate*, you may have seen by our *Atti* that I lost no occasion to boast of my title of your representative; and to forward what I thought (deprived as I was of instructions) your American scientific and philosophical views. At Genoa, where we will hold our Eighth Meeting of the *Scienziati Italiani*, on the 14th of September, things will be conducted more regularly, especially as regards deputations of Societies and Academies. I shall be proud to receive a more regular authorization, and to receive it at Genoa; and to be sure to get it in time, to the care of the Secretary General of the Eighth Congress, the *Marquis Pallavicini*. If besides the American Philosophical Society, other Societies will favour me with their letters, it will give much illustration and weight to our Italian Congresso. If any American *Savant* were travelling in Italy, I should be proud to be his colleague. The meeting will be *grand* and most interesting to Science and civilization.

I have a still more important request to make. Ceva Grimaldi, Marquis of Pietracatella, Prime Minister (*Presidente del Consiglio dei Ministri*) of the King of Naples, is a first rate literary and scientific character. He is a Tory but one of those high-minded old Tories who are much more liberal, in the good sense, than many a Democrat or Radical, (among which latter I must confess I am proud to be ranked.) He would be gratified to be enrolled among the members of the American Philosophical Society;

[8] In the American Philosophical Society Library.

and I assure you that he is such a man as would do honour to any society in Europe or America. He is already a member of the Institute of France. He has done immensely towards the memorable meeting at Naples; and it was through him that I obtained for your Society the books you asked for.

I send this scrawl to my friend Edward Everett of Boston, that he may canvass for my candidate, and take also advantage of what I say, having hardly time to drop him a word.

Signed, CH. L. BONAPARTE[9]

20. *C. L. Bonaparte to Edward Everett*

Rome June 27 1846

My dear friend

I was in such a haste the other day, that I forgot the principal episode of our Genoa meeting.—The monument by which we intend commemorating it will be a Monument to Columbus, worthy I hope of the man, thus at the same time Italy at large & Genoa particularly paying an old & sacred debt.—The medal that will be coined in that ominous circumstance will also represent *Columbus*. Please let M.r Ord & your sc. bodies be aware in good time of this double circumstance (our meeting takes place from the 14 to the 29 of Sept.) & let them send representations & furnish them with proper instructions. International relation between Am. & Italy is *my hobby;* what better circumstance than this?—I trust the whole affair into your friendly & patriotic hands!

Time presses hard even now upon me (when will it be differently?) I cannot join the papers I should like to send; but in order you should begin to know something of our Am. affairs to give at least an advice, I send you open my wife's letter to M.r Mailliard which you will forward immediately after having read it & taken notes if you think proper.

Your most aff.te friend
C. L. BONAPARTE

P. S. I should like to see something of Columbus & the Genoa meeting in the American papers. Perhaps it may also interest your sc. public at large to know that our new Pope Pius the IX has already been so kind as to assure me in my first visit to him that he would take our scientific meetings under his protection, greet them in his States & c: accepted my anticipated thoughts in the name of all & c. To these generous words was present the very prelate Mon.r Catevini who signed the circular of *darkness* which prevented Roman Prof. to join us in the preceeding meeting.[10]

[9] In the American Philosophical Society Library.
[10] Letter in the Massachusetts Historical Society.

21. *Giovanni Labus, Secretary of the I. R. Istituto Lombardo di Scienze Lettere ed Arti, to the American Philosophical Society*

Milano, 24 Giugno 1846

Al Chiarmo Sig.r Segretario della Società Filosofica Americana di Philadelphia.

La celebrità che gode in tutta Europa l'Illustre Società Filosofica Americana di Filadelfia, ha destato nell'I. R. Istituto Lombardo di Scienze, Lettere, ed Arti, recentemente richiamato a nuovo lustro da S. M. I. R. l'Imperatore e Re Ferdinando I, il vivissimo desiderio di riaprire con Essa letteraria corrispondenza, e del concambio delle proprie Memorie colle Transazioni, che cotesta Società pubblica con tanto suo plauso.

A questo effetto mi pregio di trasmettere alla S. V. Chiarma i volumi delle nostre Memorie pubblicati per gli anni 1819–1845, non che il Giornale di questo Istituto per gli anni 1841–1845.

E perchè le pervengano con sicurezza, fu incaricato della tramissione il Sig.r Pietro Rolando, celebre Librajo di Londra, al cui ricapito potranno indirizzarsi le lettere, e que' volumi delle Transazioni, che piacesse all'Illustre Società Filosofica d'inviare all'Istituto in Milano.

Nella fiducia che l'invito possa essere accolto con reciproca soddisfazione, prego la S. V. Chiarma di un cenno di riscontro per mia norma, e di aggradire le protestazioni del mio più profondo ossequio.

Il Segretario,
LABUS

22. *The American Philosophical Society to Giovanni Labus*

à M. le Docteur Giovanni Labus
Secrétaire de l'Institut royal
des Sciences, etc. à Milan

Monsieur,

Enfin, après une attente de plusieurs mois, une occasion se présente de vous envoyer les Mémoires annoncés dans ma lettre de Décembre 1846.

Je viens d'expédier par le Brick Trio, en partance de New-York pour Livourne, une caisse contenant quinze volumes in-quarto, et autres ouvrages. Cette caisse est adressée aux soins de M. John B.te Sartori, négociant de Livourne, qui vous la fera tenir suivant vos ordres.

Je vous supplie, Monsieur le Secrétaire, de vouloir bien agréer l'assurance de ma haute considération.[11]

[11] From the Letter Books of the American Philosophical Society under the date 13 December 1847.

23. *The American Philosophical Society to Pietro Savi, of the University of Pisa*

à M. Pietro Savi
Professeur de Botanique dans
l'Université de Pise
Monsieur,

La lettre que vous m'avez fait l'honneur de m'écrire, sans date, m'est parvenue le 15 Juillet dernier. La lettre ci-jointe vous fera voir que la Société Philosophique Américaine a également reçu le paquet de brochures que vous avez bien voulu lui présenter. Le paquet de semences, etc., que vous aviez adressé au Directeur du Jardin botanique de Philadelphie, a été envoyé à M. le Docteur Asa Gray, Professeur de Botanique au Collège de Cambridge, dans l'État de Massachusetts, parce qu'il n'y a point de Jardin public des Plantes dans cette ville-ci. M. le Professeur Gray est un savant distingué chez nous, et entièrement digne de votre correspondance.

Je vous prie, Monsier, de faire tenir à M. le Bibliothécaire de l'Université de Pisa le paquet que je vous envoie sous son adresse. Il contient le dernier volume de nos Mémoires, avec plusieurs Bulletins, etc., en échange du beau volume des Annales de l'Université de Pisa, qu'il a eu la bonté de nous transmettre par vos mains. Nous voilà en correspondance avec cette illustre compagnie.

Recevez les assurances des sentiments respectueux avec lesquels j'ai l'honneur d'etre
Monsieur, etc. etc.[12]

24. *George B. Wood to J. P. Lesley*

Naples. 8 May 1861

. . . I wish to say that . . . my offer of service to the Society [is] not merely formal, but the result of . . . a real wish to serve them. . . .

I was so unwell part of the time in Rome, and so much engaged in seeing its numerous sights, that I made no acquaintance with any gentlemen of science there, nor any inquiries into the state of science & scientific bodies till towards the close of my stay. On my return, however, I shall make further inquiries, &, should anything occur which I think may be of interest & importance to the Society, will write concerning it. If the Society has not now any official relations with Roman Scientific Bodies, it will be desirable, I think, to form them should the way appear to open; for the world, or at least a large part of it is now eagerly looking for the time when that city may be a great centre of national power, and all its concomitants.

I grieve profoundly over the sad state of our country; and am ready here in Italy to sink with shame when I compare the zeal & self sacrifising spirit here displayed for the formation of a Union, with the recklessness, or by whatever other name we may call it, which throws away a similar blessing already in our possession, & which was about to raise us to the pinnacle of material greatness.

Believe me, my dear Mr. Lesley,
Sincerely your friend
GEO. B. WOOD

[12] *Ibid.*

25. *George B. Wood to J. P. Lesley*

Rome, May 31st 1861.

My dear Mr. Lesley

Some time since I wrote in reply to your communication in reference to a copy, for the Philos. Society, of the newly discovered testament, printed, or to be printed at St. Petersburg, saying that, should I reach that city, as I fully expected to do, I would use my best endeavours to fulfil the charge committed to me. At present I write in reference to matters here at Rome.

I believe that the only member of our Society in this city is father Secci, a Jesuit, who was some years since in Philadelphia, where he made a favourable impression by his astronomical attainments. I have made his acquaintance, and find him an exceedingly courteous gentleman, full of zeal for the promotion of his branch of knowledge, & actively engaged in astronomical and meteorological investigations and observation. Upon inquiry, I found that he did not receive regularly the proceedings of the Society, and I think he would be gratified to get them. Will you, if in accordance with the rules of the Society, see that he is supplied? Father Secci is the Director of the astronomical observatory of the Roman College, an Institution of the Jesuits, which publishes the results of their observations regularly, having commenced a new Series not a great while ago. Before that time their observations were published, but not regularly. He told me that he would gladly send them regularly to the Society, and would begin by transmitting the published volume. I could not tell him by what route it would be best to send them; but said that I believed the Smithsonian Institute had arrangement by which works of this kind were sent to and from our country, and that they had a correspondent in Rome. If you know of any convenient mode of communication, and at the same time deem it proper to send him the Proceedings, you can, in your note announcing to him that you have done so, mention also the route by which he can send the observations of the College to you. He has published several pamphlets in a separate form, of which he was kind enough to give me copies, and will probably send others to the Society. One of these is an account of astronomical observations made by himself in a recent mission to Spain. He speaks English fluently, and would, I think, be a valuable correspondent of the Society.

There is also another matter which I wish to bring before the attention of the Society. There is a scientific association here, under the patronage of the Government, called the *Academia dei Lincei*, literally, I believe, the Academy of the Lynxes, these animals being reputed very sharp sighted. This association corresponds, in reference to Rome, as near as may be, with the Imperial Academy in Paris, and the Royal Society in Londⁿ in reference to France & England. It publishes proceedings. The President is *Prince Massimo*, and the Secretary Professor *Paolo Volpicelli*, of the Roman University. I have made the acquaintance of the latter gentleman, through the kind instrumentality of Dr. Valery, a distinguished physician of Rome, and find him a man zealous in the pursuit of knowledge. He has published several pamphlets (I think 7 in all) on various scientific subjects, of which, since I saw him, he has sent me three sets, one for myself, one for you, and one for the Am. Philos. Society. He assured me that the Academy would with pleasure enter into scientific relations with our Society; and I should be very glad to see such relations formed. An interchange of Proceedings or Transactions, as may be deemed best, would be advisable. I presume the transmission of these publications may be considered as fairly opening the way. . . . Should the scientific publications of Prof. Volpicelli be deemed such as will entitle him to honourary membership in the Society, I would be happy to join with you and any other member that may lead in his name in proposing him. From what I have learned here, he stands among the first, if not the first in Rome, in reference to physical science. It will be remembered that we have only one member here. Prof. Volpicelli is a middle-aged man, who has lost none of his energies.

Hoping to hear from you soon, with kind regards to the members of the Society, I remain

Sincerely your friend,

GEO. B. WOOD

ITALIAN EXCHANGE LIST[13]

1. Accademia Gioenia di scienze naturali: Catania.
2. Biblioteca nazionale centrale: Firenze.
3. R. Stazione di entomologia agraria: Firenze.
4. Museo civico di storia naturale: Genova.
5. R. Società italiana d'igiene: Milano.
6. R. Istituto lombardo di scienze e lettere: Milano.
7. Società italiana di scienze naturali e Museo civico di storia naturale: Milano.
8. R. Accademia di scienze lettere ed arti: Modena.
9. Accademia delle scienze fisiche e matematiche: Napoli.
10. Museo zoologico della R. Università: Napoli.
11. R. Accademia di scienze morali e politiche: Napoli.
12. Società africana d'Italia: Napoli.
13. R. Accademia di scienze, lettere e belle arti: Palermo.
14. R. Università: Pavia.
15. R. Istituto di fisica: Pisa.
16. R. Scuola normale superiore: Pisa.
17. Società toscana di scienze naturali: Pisa.
18. Osservatorio magnetico e meteorologico della R. marina: Pola.
19. R. Istituto superiore agrario: Portici.
20. Consiglio nazionale delle ricerche: Roma.
21. Giornale del genio civile: Roma.
22. R. Accademia nazionale dei lincei: Roma.
23. R. Ufficio centrale di meteorologia e geofisica: Roma.
24. Seminario matematico della facoltà di scienze della R. Università: Roma.
25. Società italiana delle scienze: Roma.
26. Società italiana per il progresso delle scienze: Roma.
27. R. Accademia delle scienze: Torino.
28. Società piemontese di archeologia e belle arti: Torino.
29. Museo di zoologia e d'anatomia comparata: Torino.
30. K. K. Maritimes Observatorium (R. Osservatorio astronomico): Trieste.
31. Pontificia accademia delle scienze: Stato della Città del Vaticano.
32. Istituto veneto di scienze lettere ed arti: Venezia.

[13] Compiled from the mailing list of the American Philosophical Society in effect at the outbreak of World War II.

ITALIAN MEMBERS OF THE AMERICAN PHILOSOPHICAL SOCIETY[14]

Official membership number			Residence at time of election	Date of election
1.	*188*	Professor Famitz.	Naples	15 April 1768
2.	*365*	Felice Fontana (1730–1805) Naturalist and physiologist. Professor in universities of Rome and Pisa. Called to Florence in 1765 by Pietro Leopoldo II as court physicist and director of the ducal cabinet of natural history.	Florence	18 January 1783
3.	*443*	Luigi Castiglioni (1752–1832) Naturalist, particularly interested in botany. Visited the United States in 1785–1787, describing his travels in *Viaggio negli Stati Uniti dell'America Settentrionale* (Milano 1790).	Milan	21 July 1786
4.	*556*	Paolo Andreani (d. in Nice, 1824) Naturalist and scientist. First Italian to ascend in a balloon (1784). Traveled widely in America.	Milan	20 January 1792
5.	*560*	Giuseppe Ceracchi (1751–1802) Sculptor. Came to America in the hope of receiving commissions from the govenment. Made portrait busts of Franklin, Washington, Hamilton, Rittenhouse. Guillotined in Paris.	Rome	20 January 1792
6.	*637*	Giambattista Scandella ". . . Man of letters and a theoretic farmer" (Latrobe). An early American traveler.	Venice	20 April 1798
7.	*794*	Carlo Botta (1766–1837) Historian, physician, statesman. Remembered especially for his *Storia della Guerra d'indipendenza degli Stati Uniti d'America.*	Turin	18 October 1816
8.	*883*	Gaspard Deabbate Consul General of the Kingdom of Sardinia to the United States.		17 January 1823
9.	*905*	Charles Lucien Bonaparte (1803–1857) Naturalist, known particularly for his orthinological studies. Son of Lucien Bonaparte, and nephew of Napoleon and Joseph. Resided in the United States 1822–1828.	Philadelphia	16 April 1824
10.	*939*	Giovanni Maria Zecchinelli Physiologist.	Padua	20 April 1827
11.	*990*	Lorenzo Martini (1785–1844) Physiologist and philosopher. Rector of the University of Turin.	Turin	15 October 1830
12.	*993*	Prospero Balbo (1762–1837) Statesman, educator, writer on economics and statistics. One of the founders of the Academy of Turin, and its president from 1821–31.	Turin	21 January 1831
13.	*994*	Giacinto Carena (1778–1859) Physicist, naturalist, lexicographer.	Turin	21 January 1831
14.	*1054*	Domenico Morelli Consul General of the Kingdom of the Two Sicilies to the United States.		15 January 1836
15.	*1143*	Bernardo Quaranta (1790–1867) Archeologist and philologist. Professor of archeology and Greek literature at University of Naples.	Naples	1 January 1841

[14] This list includes only individuals whose culture was formed in Italy and whose careers are primarily associated with that country. In accordance with that criterion, no attempt is made to claim such men, for example, as the Egyptologist, Gaston Maspero (French), nor the engineer, Théodore Turrettini (Swiss), despite their obvious racial derivation. By the same token, however, Charles Lucien Bonaparte is taken back into the fold.

Official membership number			Residence at time of election	Date of election
16.	*1174*	Leopoldo II (1797–1869) Grand Duke of Tuscany. The first part of his rule was characterized by liberalism and a progressive spirit in matters of administration, finance and education. Abdicated in 1855 in the face of growing disorders and spent the last years of his life as an exile in Austria.	Florence	20 January 1843
17.	*1229*	Giuseppe Ceva Grimaldi, Marquis of Pietracatella. Prime Minister of the King of the Two Sicilies.	Naples	16 October 1846
18.	*1283*	Francesco Zantedeschi (1797–1873) Physicist. Professor at the University of Padua.	Padua	18 April 1851
19.	*1398*	Elia Lombardini (1794–1878) Engineer. Famed for his work in fluvial hydraulics.	Milan	15 January 1858
20.	*1413*	Angelo Secchi (1818–1878) Astronomer and meteorologist. Exiled in 1848 as a Jesuit, came to America and taught mathematics in Georgetown University. Returned to Rome in 1849 to take charge of the Osservatorio del Collegio Romano, which under his direction became a famous center for the study of astrophysics and geophysics.	Rome	20 January 1860
21.	*1442*	Paolo Volpicelli (1804–1879) Mathematician and physicist. Professor in the University of Rome and secretary of the Accademia dei Lincei.	Rome	18 October 1861
22.	*1612*	Ceselli	Rome	15 January 1869
23.	*1731*	Giovanni Capellini (1833–1922) Geologist and paleontologist. Professor in the University of Bologna. Founded the Bolognese geological museum which bears his name; also, the Società geologica italiana. Promoter of various congresses, including the second International Geological Congress at Bologna in 1881. Traveled in America in 1862.	Bologna	18 April 1873
24.	*1732*	Giovanni Battista de' Rossi (1822–1894) Archeologist and epigraphist. Founder of Christian archeology. Author of many large works on Latin and Christian antiquity.	Rome	18 April 1873
25.	*1733*	Luigi Palmieri (1807–1896) Physicist and vulcanologist. Professor of philosophy at University of Naples. Director of the Osservatorio vesuviano.	Naples	18 April 1873
26.	*1892*	Damiano Muoni (1820–1894) Historian, archeologist, man of letters (obituary in *Proc. Amer. Phil. Soc.* **33**: 156, 1894).	Milan	16 January 1880
27.	*2051*	Tommaso Cannizzaro (1838–1912) Sicilian poet and Garibaldian.	Messina	16 October 1885
28.	*2057*	Giuseppe Sergi (1841–1936) Anthropologist and sociologist. Professor of anthropology at universities of Bologna and Rome. Director of the Museo antropologico of Rome. Traveled and lectured in the United States.	Rome	16 October 1885
29.	*2090*	Angelo de Gubernatis (1840–1913) Orientalist, poet, dramatist. Professor of Sanskrit and comparative glottology in the Istituto di studi superiori of Florence, and, after 1890, professor of Italian literature and Sanskrit at the University of Rome.	Florence	21 May 1886
30.	*2129*	Guido Cora (1851–1917) Traveler and geographer. Professor of geography at the universities of Turin and Rome. Founder of the important periodical *Cosmos*.	Milan	17 December 1886

Official membership number		Residence at time of election	Date of election
31.	*2145* Giuseppe Meneghini (1811–1889) Paleontologist, and professor of mineralogy at the University of Pisa.	Pisa	20 May 1887
32.	*2155* Antonio de Gregorio (1855–1930) Naturalist, and historian of music.	Palermo	21 December 1888
33.	*2267* Paolo Mantegazza (1831–1910) Anthropologist and physiologist. Established at the University of Pavia in 1858 the first laboratory of general pathology in Europe. Assumed at Florence in 1870 the first chair of anthropology in Italy. Founded the Museo antropologico-entografico of Florence, the Società italiana di antropologia, and the periodical, *Archivio di antropologia ed etnologia*.	Florence	17 May 1895
34.	*2344* Rodolfo Lanciani (1847–1929) Archeologist. Professor of Roman topography at the University of Rome. Prolific writer in both English and Italian.	Rome	15 October 1897
35.	*2387* Guglielmo Mengarini (1856–1927) Electrical engineer. Professor of electrotechnics at the University of Rome. Author of the famous hydro-electric plant at Tivoli.	Rome	20 May 1898
36.	*2461* Guglielmo Marconi (1874–1937) Electrical engineer; inventor of wireless telegraphy (obituary by W. F. G. Swann in *Year Book Amer. Philos. Soc.* for 1937: 371–375, 1938).	London	15 February 1901
37.	*2458* Enrico Hillyer Giglioli (1845–1909) Zoologist and ethnologist. Professor of zoology and comparative anatomy in the R. Istituto di studi superiori of Florence. Founder of the valuable collection of Italian vertebrates in Florence which now bears his name.	Florence	15 February 1901
38.	*2468* Giovanni Virginio Schiaparelli (1835–1910) Astronomer and historian of astronomy. Professor in the Istituto tecnico superiore of Milan and University of Pavia. Director of the Osservatorio di Brera.	Milan	15 February 1901
39.	*2708* Vito Volterra (1860–1940) Physicist. Professor at the universities of Turin and Rome. Traveled and lectured widely in the United States (obituary by S. Mandelbrojt in *Year Book Amer. Philos. Soc.* for 1940: 448–451, 1941).	Rome	25 April 1914
40.	*3167* Enrico Fermi (1901–) Physicist. Professor of theoretical physics at University of Rome. Noted for his contribution to the knowledge of atomic physics. Now at University of Chicago.	New York	21 April 1939
41.	*3232* Tullio Levi-Civita (1873–1941) Mathematician. Professor of theoretical mechanics at universities of Padua and Rome. Lectured widely in the United States (obituary by L. P. Eisenhart in *Year Book Amer. Philos. Soc.* for 1941: 352–353, 1942.)	Rome	19 April 1940
42.	*3368* Benedetto Croce (1866–) Historian, statesman, philosopher, man of letters.	Naples	21 April 1944
43.	*3417* Gaetano De Sanctis (1870–) Classical historian, archeologist, philologist. Professor of ancient history at University of Turin until 1929; since then at University of Rome.	Rome	19 April 1946

R. A. F. PENROSE, JR., MEMORIAL LECTURE

THE GENE

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(*Read April 18, 1946*)

To the layman and the scientist alike the difference between living and non-living systems is a subject of great inherent interest. Any investigation of this difference professing to have scientific value implies definitions of the terms living and non-living, and such definitions are bound to be subjective and arbitrary. This difficulty can be avoided if some unique property of living things is found that can be defined in a purely objective way. It should then be possible to determine how far an organism can be subdivided without losing this property. I share the belief of many biologists that self-duplication or replica-formation represents such a property. Replica-formation consists of the synthesis of copies identical at least in essential respects with a model. In the absence of the model, copies cannot be made in any systematic fashion.

Organisms like ourselves represent highly complex systems capable of replica-formation. Obviously a human being cannot arise *de novo*—there must be a model. That *two* models happen to be necessary in this particular example represents little more than a minor accident in the course of evolution. How much of the organism is necessary for the operation of the model-copy mechanism? Clearly a whole man is not required. A single cell of the right type, say a white blood cell, if put in a suitable tissue culture medium, is capable of indefinite replica-formation.

That the cell is a fundamental unit of higher plants and animals was clearly recognized more than a hundred years ago by Schleiden and Schwann. Their cell theory which holds that cells arise only from preexisting cells is a landmark in the development of biological sciences that is stressed by all elementary textbooks in biology. In fact, the cell theory has been so strongly emphasized and widely accepted that it has become customary to take for granted that the cell is *the* fundamental living unit. Let us examine this biological dogma by asking the question: is there a *sub*-cellular unit capable of self-duplication? The answer is clearly yes, but the proof of its existence is far less simple than for the cell. It is the gene, the unit of inheritance. It is true that it has not yet been possible to demonstrate the multiplication of genes outside the living cell, but there are reasons to believe that in the remote past they did exist and reproduce in the free state. It is possible that, if a suitable environment could be devised, such reproduction might be possible for the present-day genes of higher plants and animals.

WHAT IS THE GENE?

Classical genetics defines the gene as a unit of inheritance. Its definition in this way is dependent on sexual reproduction and on its existence in at least two forms. To illustrate, let us consider the ability of different individuals of the human species to taste the organic compound phenyl-thiourea. To seven out of ten persons this is disagreeably bitter while to the remaining three it is tasteless if taken in moderate amounts. It is a simple matter to determine the inheritance of taste reaction to this substance. The facts are accounted for by assuming a specific gene existing in two forms, a dominant one which conditions ability to taste and a recessive one carried by individuals unable to taste. Each individual starts development with a set of twenty-four chromosomes from his mother and a similar set from his father. Each set carries one or the other of the two forms of the gene concerned with taste reaction to this particular chemical. There are therefore three kinds of individuals so far as this gene is concerned. These are:

1. Individuals who receive taster forms of the gene from both parents. They are tasters.
2. Individuals who receive a taster form of the gene from one parent and a non-taster form from the other. These, too, are tasters, and

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the taster form is therefore said to be dominant.

3. Individuals who receive non-taster forms of the gene from both parents. They are non-tasters.

From these principles it is a simple matter to predict from the constitutions of parents what their children will be with respect to taste reaction. For example, the children of two parents each carrying both forms of the gene will average three tasters to one non-taster.

We are still a long way from a satisfactory understanding of genes in terms of chemical composition. Whole chromosomes have been isolated and found to be made up largely of nucleoproteins, combinations of nucleic acid and proteins (1). This suggests but does not prove that genes, too, are nucleoprotein in nature. That they at least contain nucleic acid is independently indicated by the fact that the efficiencies of different wave lengths of ultraviolet radiation in producing mutations in genes (changes in function without necessary loss of reproductive capacity) vary in a manner that parallels their absorption by nucleic acid (2). Still further evidence comes from the observation that viruses, which have several properties in common with genes, are nucleoprotein in nature or at least contain nucleoprotein.

WHAT DO GENES DO?

In the case of the gene in man known to be concerned with taste reaction to phenyl-thiourea we know very little about its mechanism of action. Indeed, relatively little is known about the mechanism of taste itself. Other genes are known which control traits more susceptible to description in terms of chemical reactions. In man, for example, the classical hereditary disease alcaptonuria results from inability of the affected individual to oxidize 2,5-dihydroxyphenylacetic acid (alcapton) in the normal fashion (3). As a consequence this compound accumulates and is excreted in the urine. In the presence of oxygen it forms a black substance which is responsible for the most striking symptom displayed by alcaptonurics, darkening of urine on exposure to air. It appears that in the presence of the normal form of the gene the breakdown of alcapton occurs while in the absence of this normal form, i. e., in the presence of the defective form only, this degradation cannot be accomplished.

Within recent years a number of additional instances have been recorded in which genes obviously exert a control over specific and known biochemical reactions. One of these of particular interest in human genetics concerns the type of feeblemindedness known as oligophrenia phenylpyruvica in which phenylpyruvic acid is excreted in the urine instead of being oxidized to its para-hydroxy analogue as it is in normal individuals (4). This association of genetic inability to carry out a specific chemical transformation and the impairment of the central nervous system constitutes a most important clue in our search for knowledge as to how the nervous system operates.

In plants several chemical transformations in the anthocyanin pigments are known to be under genetic control, for example, the reduction of cyanidin to pelargonidin, the oxidation of cyanidin to delphinidin, and the reduction of quercitin to cyanidin (5).

In the vinegar fly Drosophila some twenty-five genes are known to be directly concerned with the elaboration of eye pigments. These have to do with the formation of at least two pigment components. In the formation of one of these, the brown water-insoluble one, two gene-controlled diffusible substances or eye-color hormones intervene (6).

In the rabbit the presence of the enzyme that catalyzes the breakdown of atropine has been shown by Sawin and Glick (7) to be dependent on the dominant allele of a specific gene. In a similar way the presence of certain sugar-splitting enzymes in yeast is known to be gene-dependent (8).

In certain leguminous forage crops, stock poisoning is sometimes encountered owing to the liberation of hydrocyanic acid from the hydrolytic breakdown of cyanogenetic glucosides. This breakdown is enzymatically catalyzed and in the case of white clover the presence of the enzyme has been shown to be dependent on the activity of a specific gene (9). We have here another example of the control of a known chemical reaction by a specific gene in which it is clear that an enzyme acts as an intermediary.

EXAMPLES OF GENE CONTROLLED REACTIONS IN NEUROSPORA

Because genetics and biochemistry have developed more or less separately, there has been little conscious selection of organisms on the basis of their being simultaneously suited to the techniques of both disciplines. The heterothallic

ascomycetous fungus *Neurospora crassa* is exceptional in this respect and has been deliberately selected for work in chemical genetics (10). Dodge (11) is to a large extent responsible for its discovery as a useful organism for studies in classical genetics, while Lindegren (12) has been a leading contributor in the actual studies themselves.

Neurospora is a fungus having multinucleate hyphae in which the nuclei each carry seven chromosomes, the haploid number (13). When opposite mating types are brought together, sexual fusion occurs in which diploid zygote nuclei are formed. The diploid state does not persist and the first two nuclear divisions following the formation of the zygote nucleus constitute the meiotic divisions. These occur in long narrow sac-like structures known as asci. The division spindles lie along the long axis of the ascus and the nuclei seldom slip by one another. Following the meiotic divisions there occurs a mitotic division. The eight nuclei resulting from the three successive divisions are included in a like number of sexual spores or ascospores.

Vegetative reproduction through asexual spores —conidia or microconidia—or mycelial fragments occurs readily. The life cycle is shown diagrammatically in figure 1.

Neurospora flourishes on a medium containing inorganic salts, a carbon and energy source such as sucrose, inorganic nitrogen in the form of nitrate or ammonium salts, and the vitamin biotin (14). Standard bacteriological techniques are made use of in growing it in pure culture. From the ingredients of the simple basic medium mentioned above the mold obviously elaborates all the constituents of its protoplasm. These include the amino acids, vitamins of the B-group except biotin, purines, pyrimidines, etc.

If genes serve to direct the specificities of enzymes and thus to control the chemical reactions that make up the organism, it should be possible by inducing gene mutations with x-rays or ultraviolet radiation to modify a normal strain of Neurospora in such a way that it would no longer be able to make some essential component of its protoplasm. If this component were some known substance such as a vitamin or an amino acid that could be supplied from the outside, growth should be possible in the presence of the needed substance in the culture medium but not in its absence.

These considerations have been translated into experimental practice (10). Asexual spores are treated with a mutation-producing agent and are then combined with an untreated strain of the opposite mating type. From the resulting fruiting bodies, single ascospores are isolated and grown on a medium containing many biologically active compounds. If a gene essential to the synthesis of thiamin had been mutated in the treatment, there would be a chance of recovering the descendants of the modified gene among the single spore progeny. A spore carrying such an incapacitated form of a gene essential for thiamin synthesis would give rise to a strain dependent on an external supply of thiamin and would not survive unless thiamin were present in the medium on which the spore originally germinated.

Since as yet there is no known method of directing mutations, it is not possible to anticipate the growth requirements of mutant strains produced by the method described. It is therefore essential to grow the single ascospore descendants of the treated material on a medium containing a large array of growth factors if efficient recovery of mutant strains is to be achieved.

Strains that grow on the supplemented medium are tested for synthetic ability by transferring them asexually to basal medium as indicated in the diagram. When this is done about ninety-nine of every hundred single spore strains prove to be like the original and grow normally. But one or two out of every hundred—if the treatment has been successful and the dose sufficiently high—fail to grow on the basal or minimal medium. Such strains are tested further as indicated. It often happens, as in the example diagrammed, that one specific compound added to the basal medium restores normal growth. It is then presumed that the mutant strain has lost the ability to synthesize the compound in question.

Mutant strains that grow only in the presence of a specific substance not present in the original minimal medium are tested genetically by crossing them to the original wild type strain of opposite mating type. From the fruiting bodies produced in such a cross spore sacs are taken and the ascospores removed in order. These are then planted individually in culture tubes in which a medium containing the required growth factor is present.

On transferring the eight single ascospore daughter strains to culture tubes containing only basal medium, one or the other of two results is obtained. In both of these four of the eight

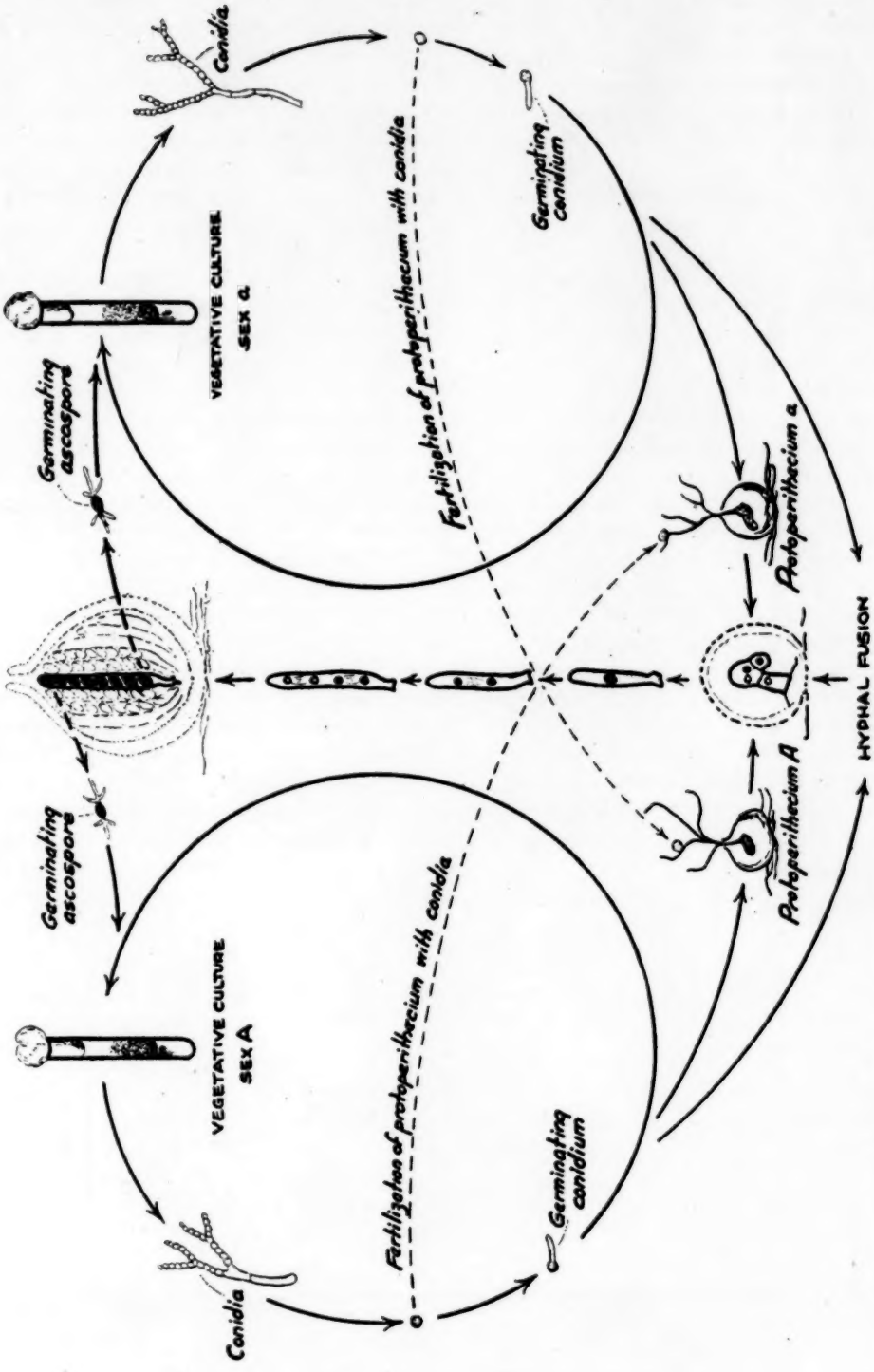

FIG. 1. Diagram of the life cycle of *Neurospora crassa*. In addition to the asexual cycle shown, the mold is able to multiply asexually by microconidia and by means of fragments of the mycelium. From the *American Scientist*.

spores of a single ascus give rise to strains like the original wild type parent and four give descendants like the mutant parent. But the arrangement may be either alternating pairs or two groups of four. Alternating pairs—second division segregations—result from crossing over between the centromere and the gene pair concerned.

The frequency of second division segregations relative to first division segregations which give rise to two groups of four descendants is a direct measure of the frequency of crossing over between the gene involved and the centromere. This in turn is a measure of the distance of the gene being studied from the centromere of the chromosome in which it is carried. It is therefore a simple matter to determine how far any gene which exists in two forms is from the centromere. This procedure is the essential basis of the technique by which the geneticist determines the relative locations of genes in chromosomes. In organisms whose life cycles are not as convenient genetically as that of Neurospora, the method of making chromosome maps takes a somewhat different, and in some respects less simple, form.

From approximately 70,000 single spore strains that have been tested several hundred mutant strains have been obtained that require specific supplements to the basal medium for normal growth (15). These include strains requiring most of the B vitamins, many of the essential amino acids, and a number of other compounds of biological interest.

Among fifteen mutant strains requiring for growth arginine or some related substance Srb and Horowitz (16) have identified seven genetically distinct types, each type differing from the original by a single gene but in each case by a different gene. Four of these grow if supplied with ornithine, citrulline, or arginine and are presumed to be unable to synthesize ornithine from the constituents of basal medium. Two grow if supplied citrulline or arginine, but do not respond to ornithine. They apparently cannot convert ornithine to citrulline. One strain requires arginine for growth and cannot make use of either ornithine or citrulline. It evidently cannot carry out the reaction by which citrulline is transformed to arginine. The interpretation of arginine synthesis in Neurospora offered by Srb and Horowitz is diagrammed in figure 2. The part played by the mutant strains in working out this scheme is obvious. It is of interest to note that the ornithine cycle of Neurospora is much the same as that postulated for the mammal by Krebs.

A second instance in which mutant strains have been of use in determining the manner of biosynthesis of a compound of universal biological importance is that involving the amino acid tryptophane. Tatum, Bonner, and Beadle (17) have found that there are two genetically distinct types of mutant strains which grow poorly on minimal medium but which respond strikingly to supplements of tryptophane. Both utilize indole while only one can make use of anthranilic acid for growth. The scheme of biosynthesis of tryptophane proposed by Tatum and Bonner (18) on the basis of studies of these mutants is shown in

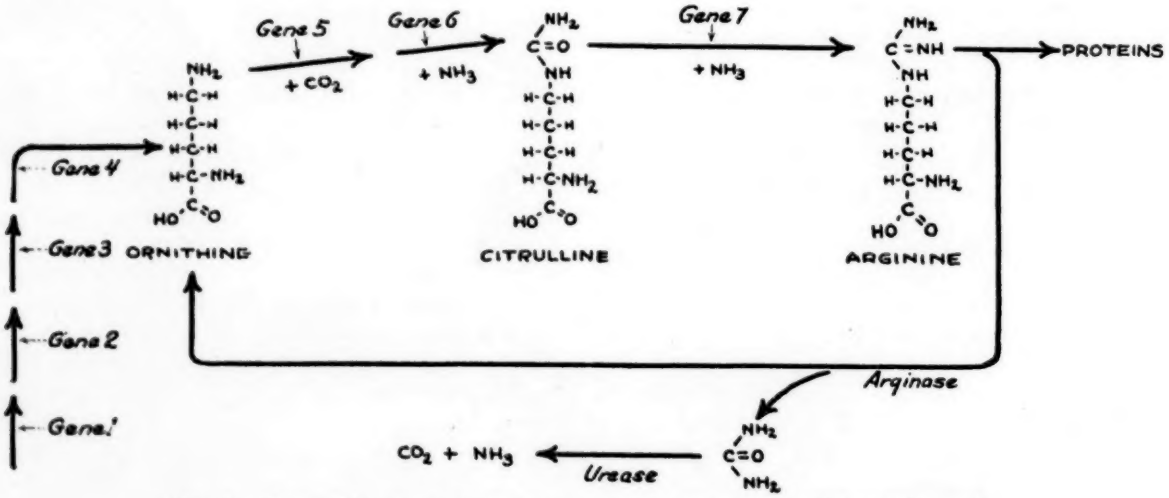

FIG. 2. The ornithine cycle in Neurospora. Based on work of Srb and Horowitz.

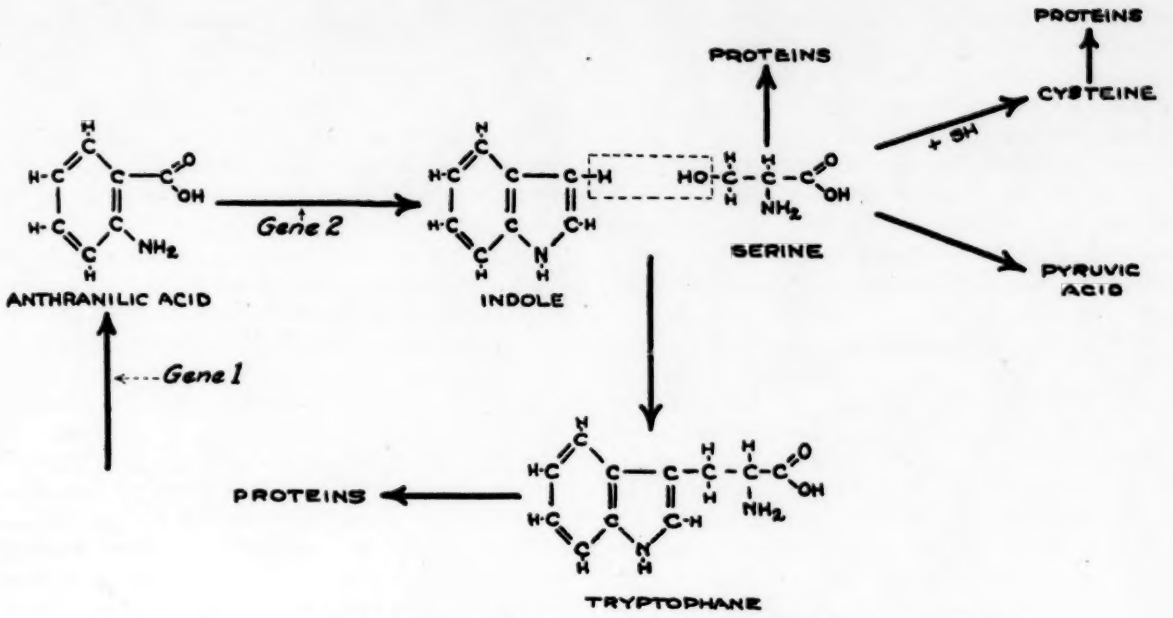

FIG. 3. Tryptophane synthesis in Neurospora. Based on work of Tatum and Bonner.

figure 3. It seems likely that most, if not all, plants make tryptophane from indole and serine, and indole, in turn, from anthranilic acid.

Horowitz (19) has demonstrated that monomethylaminoethanol is a precursor of choline in Neurospora. Again this was demonstrated through the use of two mutant types, one of which cannot make monomethylaminoethanol and the other of which cannot methylate it to form choline (fig. 4). The latter strain, when grown on small amounts of choline, accumulates the monomethyl analogue and releases it into the culture medium. Horowitz has succeeded in isolating the precursor in pure form and in identifying it chemically.

Such examples as these not only constitute convincing evidence that genes are somehow concerned in the direction of chemical reactions but emphasize the point that genetics can be a most useful tool in the hands of the biochemist who knows how to make use of it. Additional examples of the same general nature could be described—they have been summarized elsewhere (20).

HOW DOES THE GENE DIRECT CHEMICAL REACTIONS?

While we do not know in detail how the gene multiplies (21), we can be reasonably sure that the synthesis of protein and nucleoprotein is in-

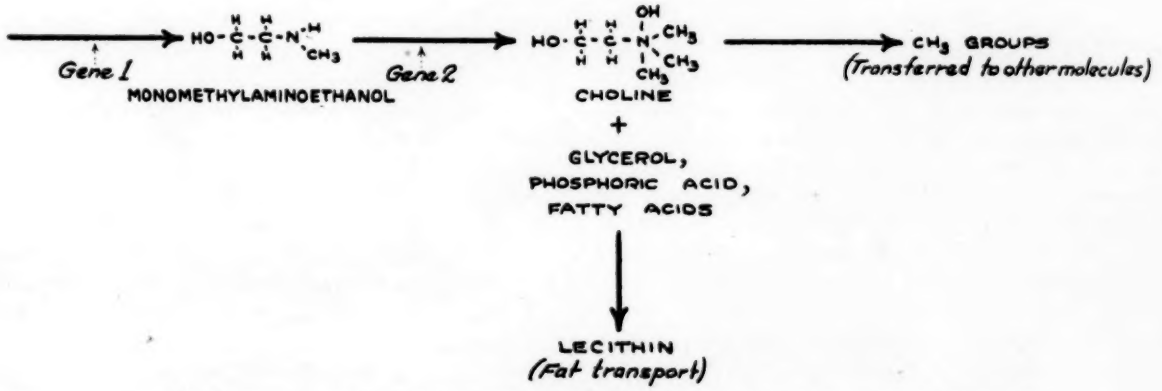

FIG. 4. Genetic control of choline synthesis in Neurospora. Based on work of Horowitz.

volved in the process. At least the final configurations that give these giant molecules their specificities must be determined during the course of duplication. If in forming replicas of themselves genes do direct protein synthesis, it seems highly probable that in essentially the same way they supervise the construction of non-genic proteins. Such proteins may serve as body proteins, as antigen constituents or as the components of enzymes. On this basis the known intimate relation between genes and antigens becomes intelligible (20, 22). Enzyme activity would likewise be expected to be dependent on genes, often with a one-to-one relation (20, 22, 23, 24). While much additional evidence is desirable before accepting as a broad generalization the view that genes act primarily by serving as templets from which the various protein species of an organism are copied, this hypothesis is an attractive one on logical grounds and has already adequately demonstrated its heuristic value.

EVOLUTIONARY CONSIDERATIONS

It is widely believed that the phenomena of gene mutation and chromosome rearrangement provide a sound basis for the process of organic evolution (25, 26, 27). While it is not the purpose of this paper to discuss the subject of evolution in general, there are two aspects of it that I should like to mention briefly. The first concerns specialization through loss of function. Starting with a complete autotroph such as a green plant, or with a non-parasitic heterotroph, it is easy to see how abilities that are not advantageous to the organism will be lost through gene mutation. This tendency is of course most striking in the modifications developed in connection with the parasitic habit. They are well known in the nutrition of protozoa (28), bacteria (29), and other forms of life (30). The genetic basis of such specialization is well illustrated in the work on mutant strains of Neurospora that have lost the ability to carry out specific syntheses (31). As an example we may consider the ability to synthesize the vitamin thiamin. Normal strains of a fungus synthesize this vitamin, but mutant strains are known in which it cannot be made. In the absence of an external supply of vitamin B_1 such a mutant strain cannot survive, but in the presence of B_1 it appears to suffer no disadvantage. Because loss mutation is more frequent than its reverse counterpart, a Neurospora strain grown continuously in the presence of vitamin B_1 would be expected eventually to lose the ability to synthesize it. The same situation holds for other B-vitamins and for many of the amino acids that go to make up protoplasmic proteins. Man represents an organism in which such loss evolution has gone so far that external supplies of most if not all of the B-vitamins and many of the amino acids are essential for survival.

How far can this type of specialization go? This question is important to our general theme because we would expect on theoretical grounds that in parasites it could go to the absolute limit, at which point we would expect to find remaining a structure possessing little beyond the power of self-duplication. In other words, we might let this process of progressive simplification of the organism tell us what is the ultimate unit possessing the power of replica-formation.

From the point of view of their dependence on external supplies of various biologically important chemical compounds, we find a more or less continuous series of organisms starting with autotrophic forms and working down through a series that can be illustrated by the following categories:

1. Autotrophic forms that require only inorganic compounds plus energy from light or inorganic chemical reactions. Examples: green algae, iron bacteria, sulfur bacteria.
2. Forms dependent on inorganic salts plus organic molecules capable of supplying carbon and energy. Example: the bacterium *Escherichia coli.*
3. Forms dependent on inorganic salts, a source of carbon and energy plus specific preformed organic molecules such as vitamins and amino acids found outside living organisms. Example: the bacterium *Lactobacillis casei.*
4. Forms dependent on inorganic salts, a carbon and energy source, plus preformed organic molecules so numerous and complex that they have not yet been made available to the organism except in the form of suitable kinds of living protoplasm. Example: the rickettsias which are small bacteria-like organisms.
5. Forms similar to the above category but so small as to be capable of passing through filters that remove ordinary bacteria. Example: psittacosis viruses—viruses that stain like bacteria and can be seen with a visible light microscope.
6. Crystallizable molecular viruses made up of nucleoprotein. They multiply only in liv-

ing protoplasm. Example: tobacco mosaic virus.

The last category would seem to represent the ultimate in parasitic specialization where nothing is left of the organism but a complex nucleoprotein molecule capable of self-duplication in the presence of an array of constituent parts such as are found in the living cell. That disease-producing viruses have arisen by retrogressive evolution through some sequence similar to that indicated is a view that has much to recommend it and one that has often been proposed (32). It has also been suggested that viruses and genes have much in common (23, 33) and that viruses might well represent parasitic degeneration carried to the extreme limit at which only a single gene remains of the parasite (32). An alternative view that must also be given serious consideration is that viruses arise directly by mutation from nucleoproteins of the host without going through the entire retrogressive evolutionary sequence outlined above (34).

The second aspect I should like to consider concerns positive evolution. It is easy to imagine an evolutionary process by which the organism degenerates to the simplest structure capable of reproduction, but it is far less simple to understand how an autotrophic plant like a sulfur bacterium or a green alga came to be in the first place. One hypothesis assumes that out of inorganic molecules there appeared through chance combination a molecule with the property of self-duplication and that all life evolved from this through mutation and selection Since the simplest substance that we know of with the power of making copies of itself is a nucleoprotein that is enormously more complex than the inorganic materials from which it could have arisen, it is literally inconceivable from a chemical standpoint that it could have originated in a single step. If for the sake of argument we assume this difficulty surmounted, how could such a unit carry out the reactions necessary to make duplicates of itself? If it were a protein, it would have to synthesize protein to reproduce and this would involve many chains of chemical reactions. Furthermore, the ability to carry out one of these reactions would by itself be of no use unless this chanced to be the terminal step in the chain.

Oparin (35) has suggested that the first self-duplicating unit to arise and persist probably did not evolve from inorganic materials but instead came only after a long pre-life evolutionary period during which organic molecules of many kinds accumulated. In the absence of living organisms to break them down such organic substances would have had a much greater chance of surviving than they would have under present-day circumstances. Furthermore, there is every reason to believe that, with the great variety of conditions that must have existed before the first replica-forming molecule arose, organic molecules would have arisen in great variety although perhaps at a rate of practically zero.

Horowitz (36) has made a suggestion as to how in an environment such as Oparin postulates an orderly process of evolution could give rise to systems capable of carrying out chains of reactions, once the first self-reproducing unit arose. In the reproduction of this first unit—the protogene—various component parts would necessarily have been taken from the medium in which it found itself. Let us represent one of these component parts by the symbol CP. This might, for example, have been an amino acid. If it were potentially possible for CP to be formed from D, D to come from B, and B to arise from A, the following reaction scheme could be written:

$$A \rightarrow B \rightarrow D \rightarrow CP.$$

A, B, D, and CP might all have been available to the protogene but it originally would have been dependent for reproduction on CP. Eventually CP might have been lowered in concentration so as to have become limiting. A mutation of the protogene to a true gene of such a nature that it could have catalyzed the reaction $D \rightarrow CP$ without loss of its power to reproduce would have had a strong selective advantage. But, finally, D, too, would have become limiting. In this event a mutation of an original protogene to a gene capable of promoting the reaction $B \rightarrow D$ would likewise have had a selective advantage if it had established a symbiotic relation with the first mutant gene. In other words, $gene^{-1}$ and $gene^{-2}$ could together have carried out the sequence of reactions $B \rightarrow D \rightarrow CP$. In the same way $gene^{-3}$ could have arisen so that the resulting three-gene symbiotic system could have reproduced in the presence of A, B, D, or CP through its ability to carry out the entire reaction chain,

$$A \rightarrow B \rightarrow D \rightarrow CP.$$

In a manner similar to this any reaction sequence could have been built up by adding the

steps one at a time starting with the end product of the sequence and working back to inorganic molecules. Each addition would itself have conferred a selective advantage. While the number of steps required is large and the difficulty of imagining the process in detail is great, the principle is simple. I believe this Oparin-Horowitz hypothesis to be the most satisfactory one we have by which to account for the evolution of complex organisms from the compounds present in the pre-life world.

Progressive and retrogressive evolution are probably different aspects of a single process. From the protogene autotrophic organisms arose, and from these, in turn, protogene-like viruses have recurred by a reversal of the process. Viruses are not free-living today because suitable environments no longer exist except in the presence of living protoplasm.

Whether or not the concept of the gene presented here is correct in detail, there can be no doubt the mechanism of replica-formation is basic to an understanding of the physico-chemical nature of the organism. All growth involves the multiplication of protein molecules, and we cannot therefore hope to gain more than a superficial knowledge of either normal or abnormal growth processes until we learn much more than we now know about this multiplication. Our ignorance of the nature of viruses and the manner in which they produce disease must likewise remain profound so long as the manner of duplication of these elementary units remains obscure.

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